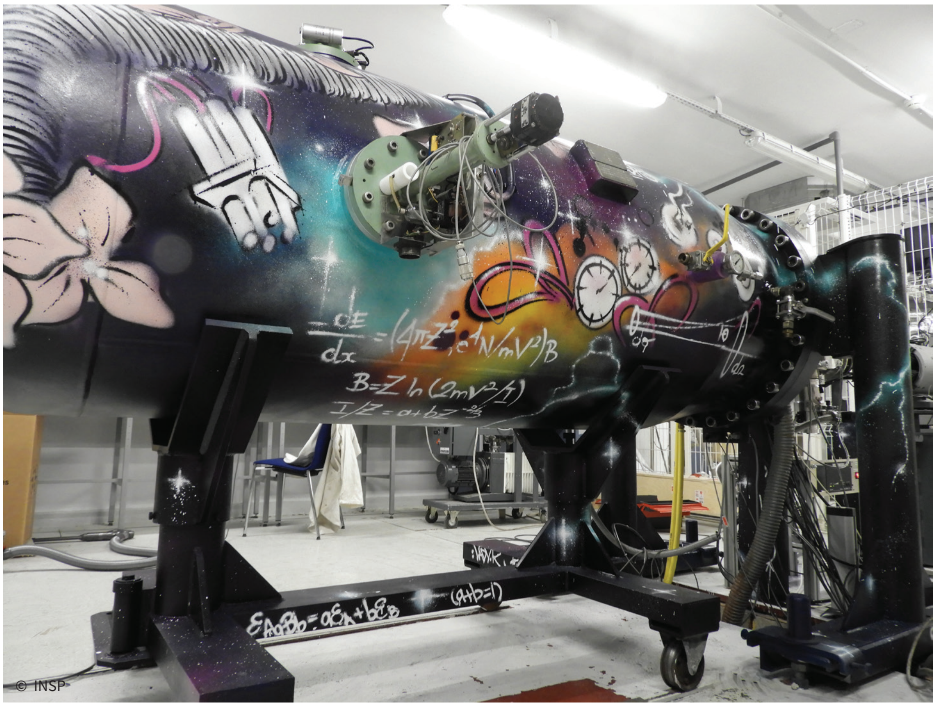
Issue # 4 - February 2021

Newsletter

RADIATE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In this edition read about:

Out with the old, in with the new

The year 2020 is one for the history books. It was a year full of tragic human loss and of fundamental changes to our day-to-day life.

COVID-19 was the biggest topic of the year. Despite the best efforts by medical professionals, scientists and governments, we can expect it to still dominate the first half of 2021. As of the 27th January 2021, more than 100 million cases of COVID-19 have been recorded worldwide, with 26% of the cases originating in the US, followed by India (11%) and Brazil (9%). Europe has had over 29 million cases with more than 622,000 confirmed deaths. Whilst such statistics are daunting and upsetting, the emergency approval of four different vaccinations against COVID-19 gives us hope for a brighter and healthier future. For more information on the newly approved COVID-19 vaccines, see here:
mRNA vaccines: https://www.compoundchem.com/2020/12/02/rna-vaccines/
Viral vector vaccines: https://www.compoundchem.com/2020/12/02/rna-vaccines/

The election of Joe Biden as the soon-to-be 46th President of the United States is expected to put an end of the anti-science crusade which characterised the Trump administration. Whilst President-elect Biden is expected to re-join the Paris climate change agreement and the World Health Organisation (WHO), one would expect many uphill political battles to come in America's road to recovery.
Finally, we could not forget Brexit. 2020 was the "transition period", the year for negotiating the future relationship between the UK and the EU. Despite delays brought on by the pandemic, an agreement was reached on Christmas Eve – perhaps an unwanted present for 49% of the UK's population! Whilst the full impact of the divorce is yet to be experienced, the continued participation of UK institutions in Horizon Europe research programmes has been assured.
Whilst the events of 2020 have plunged us into unexplored depths, it also provided us with opportunities to reach new heights. As we welcome 2021, let us be heedful of the lessons we have learnt and be thankful for all the things we have achieved, no matter how small.

Catia Costa

RADIATE Contact

www.ionbeamcenters.eu

NEWSLETTER EDITORIAL

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Virtual tour of ATOMKI's Tandetron Laboratory

Take a Youtube tour through ATOMKI's Tandetron lab and get to know the Tandetron accelerator and research facilities at the endstation of the beamlines. Four beamlines are dedicated to IBA, the others are used for fundamental research. The IBA beamlines include: the nuclear microprobe (1 µm spot size, PIXE, RBS, etc.), the nanoprobe (200 nm initially, to be improved now), millibeam (PIXE, RBS, IBIL, ERDA, channeling), and the external beam (PIXE, and irradiations of liquid samples). More information is available on ATOMKI's official website - https://www.atomki.hu/en/instruments/view/43

Surrey joins HZDR-led COST Action CA19140 Focused Ion Technology for Nanomaterials

A COST Action proposal led by Dr Gregor Hlawacek (HZDR) officially started in October 2020 and will run until October 2024. The network, which includes 27 partners countries participating across universities, research labs and instrument manufacturers, aims to create a coordinated effort in the field of ion beam based nano-engineering. The Action brings together developers and end-users to empower the development of better tool sets for identification, fabrication and characterization of next generation functional nanomaterials.

Dr David Cox from the Surrey Ion Beam Centre is one of the UK Management Committee members.
More information can be found here on the COST website.
A press release is available on the HZDR website.

If you are interested in joining the Action, you will have to register with COST and fill in the google sign up sheet:
https://forms.gle/uPvycqrRWpy1sP4j7

Update on RADIATE RBS of Quality Assurance Wafers Round Robin

Surrey IBC, UK; IRB, Croatia; IST, Portugal; INFN, Italy

As part of its ion implantation quality assurance (QA) procedures the Surrey Ion Beam Centre (IBC) carries out periodic RBS measurements of implanted Si wafers. Two wafers are implanted with As or Sb at a known energy for a set fluence. RBS measurements are then carried out at 5 evenly distributed points on each wafer. Two standards, Au/Ni/SiO2 [J.L. Colaux and C. Jeynes, Analytical Methods 7 (2015) 3096-3104] and SPIRIT [J.L. Colaux and C. Jeynes, Analytical Methods 6 (2014) 120-129] are also measured to enable determination of the necessary calibration parameters.

In order to check and determine the variation in the determined fluence of a set of As implanted QA wafers by different analysts, a round robin with several participants from the IBC was performed. This internal round robin was subsequently opened up to laboratories within the RADIATE network, including the Institut Ruđer Bošković (IRB), Instituto Superior Técnico (IST) and Istituto Nazionale di Fisica Nucleare (INFN). All participants were given the experimental conditions (i.e. incident ion and energy, detector angles, collected charge, real and live times) and the raw data and asked to perform the analysis as they saw fit.

Both the SIMNRA and the IBA DataFurnace software packages were used to perform the analysis with some different participants using different procedures. Comparison of the results shows that all the analysts agree within the experimental uncertainty of 3%. However, there is a statistically significant difference between the fluences determined by the different analysts which we continue to investigate. This is believed to be due to the subtraction of background in the spectrum. We are therefore planning to repeat the round robin with low background data to test this hypothesis.

We are planning to publish the results in the near future as part of the RADIATE Report Series which will be freely available from the RADIATE repository.

Exploration of Matrix Effects in Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) Imaging of Cisplatin-Treated Tumors

Calum J. Greenhalgh, Ellie Karekla, Gareth J. Miles, Ian R. Powley, Catia Costa, Janella de Jesus, Melanie J. Bailey, Catrin Pritchard, Marion MacFarlane, J. Howard Pringle, and Amy J. Managh

https://pubs.acs.org/doi/10.1021/acs.analchem.0c01347

A recent study by Loughborough University (UK) and the Surrey Ion Beam Centre published in Analytical Chemistry, has shown how total-ion beam analysis (t-IBA) can be used to explore potential matrix effects in laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) analysis. LA-ICP-MS can produce spatially resolved elemental maps in a sample and has found applications in bioimaging. However, similarly to other mass spectrometry imaging techniques, it is prone to matrix effects at the ionisation stage. Ion beam analysis is a regarded as a matrix effects-free technique and in this case, was used to cross check the resulted produced by LA-ICP-MS. Cisplatin, a platinum (Pt) containing chemotherapeutic drug, is used in the treatment of solid tumours such as non-small cell lung cancer (NSCLC). The article reports on the distribution of platinum at the cellular level in NSCLC explant models after treatment with clinically relevant doses of cisplatin. LA-ICP-MS results showed the correlation between platinum signals, from cisplatin, with carbon deposits in the lung tissues. Using t-IBA the authors showed that the high concentration of Pt in the carbon deposits is unlikely due to matrix effects. This can have implications for effective cisplatin distribution in lung cancer patients, who often have a history of smoking, and have therefore an increased likelihood of carbon deposition in their lungs.

Dependence of MeV ToF SIMS Secondary Molecular Ion Yield from Phthalocyanine Blue on Primary Ion Stopping Power

Marko Brajković, Marko Barac, Iva Bogdanović Radović and Zdravko Siketić

https://pubs.acs.org/doi/abs/10.1021/jasms.0c00080

Beside the lateral resolution of the setup, one of the crucial parameters for molecular imaging using Secondary Ion Mass Spectrometry (SIMS) is the secondary ion yield defined as a number of secondary ions per primary ion. The higher the yield, the lower damage is introduced to the sample surface and less time is required to obtain the image. Previous measurements have shown the electronic stopping power of the primary ion to have a major infuence on the secondary ion yield.

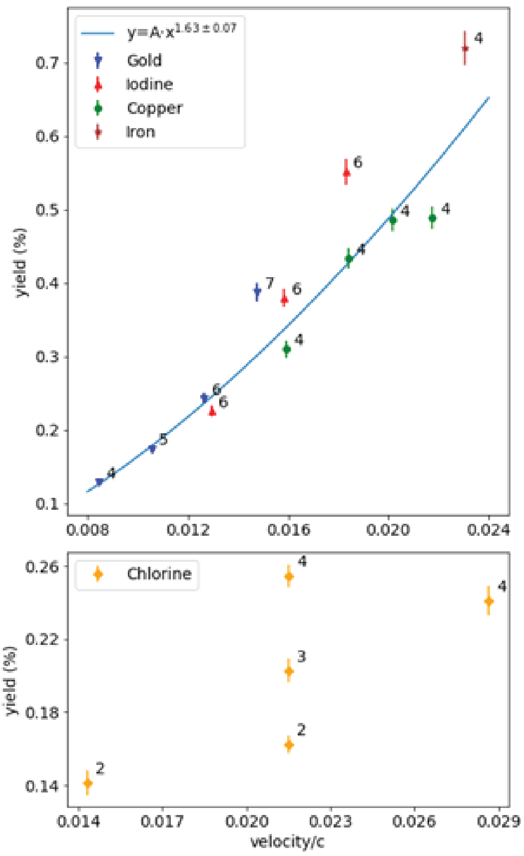
In the article recently published in the Journal of the American Society for Mass Spectrometry (https://pubs.acs.org/doi/abs/10.1021/jasms.0c00080) the group from the Ruđer Bošković Institute in Zagreb measured the secondary ion yield of phthalocyanine blue ($C_{32}H_{16}CuN_8$, organic pigment, m = 576.1 Da). Measurements were performed at the recently completed capillary microprobe that can accept and collimate heavy ion beams with arbitrary energy (up to 20 MeV Au in this study). Reflectron Time-of-Flight analyser was used for the mass analysis. Different primary beams were used to study the influence of the primary beam parameters such as energy, ion type and charge state on the secondary ion yield.

It was found that absolute values of molecular yields are lower than 1%, with the lowest yield of 0.05% for 8 MeV Si^{2+} and the highest yield of 0.72% for 14 MeV Fe^{4+}. Secondary molecular yield is increasing with increasing primary ion energy for all ions, as can be seen in Fig 1. For Cu, Fe, I and Au ions, the molecular yield is higher for lighter ions over the whole energy range shown. Also, concerning the primary ion charge state, a higher yield was measured for a higher charge state of ions having the same energy.

Electronic stopping power was calculated using program CasP which takes the initial charge states of primary ions into account, and results show an increase in secondary ion yield with the increase of electronic stopping power of the primary ion. However, there is no single curve that can describe all the data for different primary ions. Copper shows a stronger dependence than Au, Cl an I ions, but neither show one predicted by some of the models (quadratic or fourth power of electronic stopping). On the other hand, similar behavior to the Si data can be found in previous results. These deviations from the stopping dependence for neutrals, for which yield is proportional to the third power of electronic stopping, confirm again the importance of ionization part of the sputtering process, inadequately described by the existing models.

Primary ion velocity has been shown to be a better yield predictor than its electronic stopping power: the yield for Fe, Cu, I and Au increases nonlinearly with the primary ion velocity. These results can be qualitatively described by the ion track model. One exception is a chlorine where velocity (or energy) has almost no effect on the yield whose rise is perfectly correlated with the charge state of chlorine ion. The influence of the charge state is even stronger for the silicon, but there is no data to draw hard conclusions due to inability to obtain charge states higher than 5.

It is interesting that the highest yield was obtained for 14 MeV Fe^{4+}, although it does not have the highest velocity nor the highest electronic stopping power. To choose the optimum ion, one must obviously find a delicate balance on the higher end of the available values for these two quantities. More data with different samples and primary ions is needed to clear the picture about the validity and applicability of current theoretical models.



Yield of the phthalocyanine blue main molecular peak (m/q = 575-578 Da) as a function of primary ion velocity. The charge state of the primary ion is written next to each data point. The best fit is shown for the first data set. © Anal. Chem.

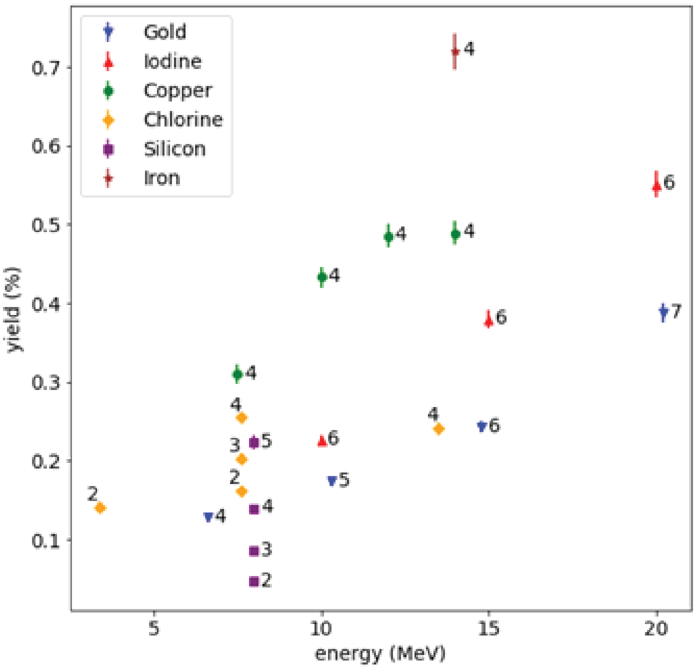


Fig.1 Yield of the phthalocyanine blue main molecular peak (m/q = 575-578 Da) as a function of primary ion energy. The charge state of the primary ion is written next to each data point. © Anal. Chem.

Studying the diffusiophoresis-driven stratification of polymer films using elastic recoil detection

M Schulz, R W Smith, R P Sear, R Brinkhuis, J L Keddie

https://pubs.acs.org/doi/abs/10.1021/acsmacrolett.0c00363

Multi-layered polymer coatings have various applications in industry e.g. in pharmaceuticals or automotives. Polymer mixtures that separate into their components during drying are called stratifying. Finding a way to control and harness stratification could potentially cut down the time and cost for application of multi-layered coatings.

An important parameter for stratification is the so called Peclèt number. The Peclèt number (Pe) describes the ratio of the evaporation speed of the mixture and the diffusion speed of the particles. If diffusion speed is small compared to evaporation speed then Pe>1 and particles accumulate at the descending interface during drying (see Figure 1). It is at this limit that stratification is expected to occur.

A theoretical model developed by Richard Sear (University of Surrey) and Patrick Warren (Unilever) is attributing stratification to the effect of diffusiophoresis, meaning here the motion of a large colloid particle in a gradient of a smaller polymer. In theory greater gradients cause stronger stratification. The gradients are influenced by the Peclèt number through the evaporation speed.

Elastic recoil detection (ERD) is of great use in polymer chemistry studies. It enables depth profiling of hydrogen and deuterium containing compounds in polymer films to be carried out. In contrast to Rutherford backscatter-ing spectrometry (RBS) where backscattered ions are detected, an ion beam is used for forward recoil atoms from the sample. In conventional ERD He ions are typically used to recoil hydrogen and deuterium. In an article recently published in ACS Macro-Letters, researchers from the Physics Department at the University of Surrey, UK, have used conventional ERD at the Surrey Ion Beam Centre to determine the depth distributions of deuterium-labelled poly(acrylic acid) dPAA in a liquid coating. RBS was carried out simultaneously to determine the carbon and oxygen concentration in the films.

For the experiments a small deuterated polymer (dPAA) and a large hydrogenated colloidal particle were blended together. This liquid coating was then applied to silicon wafers and dried at various temperatures on a heat plate. The aim of the experiments was to vary the evaporation speed of the liquid and thus the Peclèt number and the resulting stratification behaviour. Figure 2 below illustrates the difference in distribution of the deuterated component for the fastest (a) and the slowest (c) evaporation rate. For the fast evaporation a large excess of deuterium, is found close to the surface whereas the slow evaporation barely shows deuterium at the surface. The results confirm the theoretical model predictions.

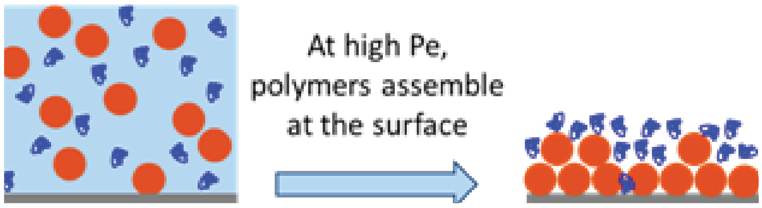


Figure 1. During drying of a mixture of colloidal particles (orange) and polymer coils (blue), the smaller polymers can assemble at the interface if the Peclèt number is sufficiently high. ©2020 MacroLetters, ACS

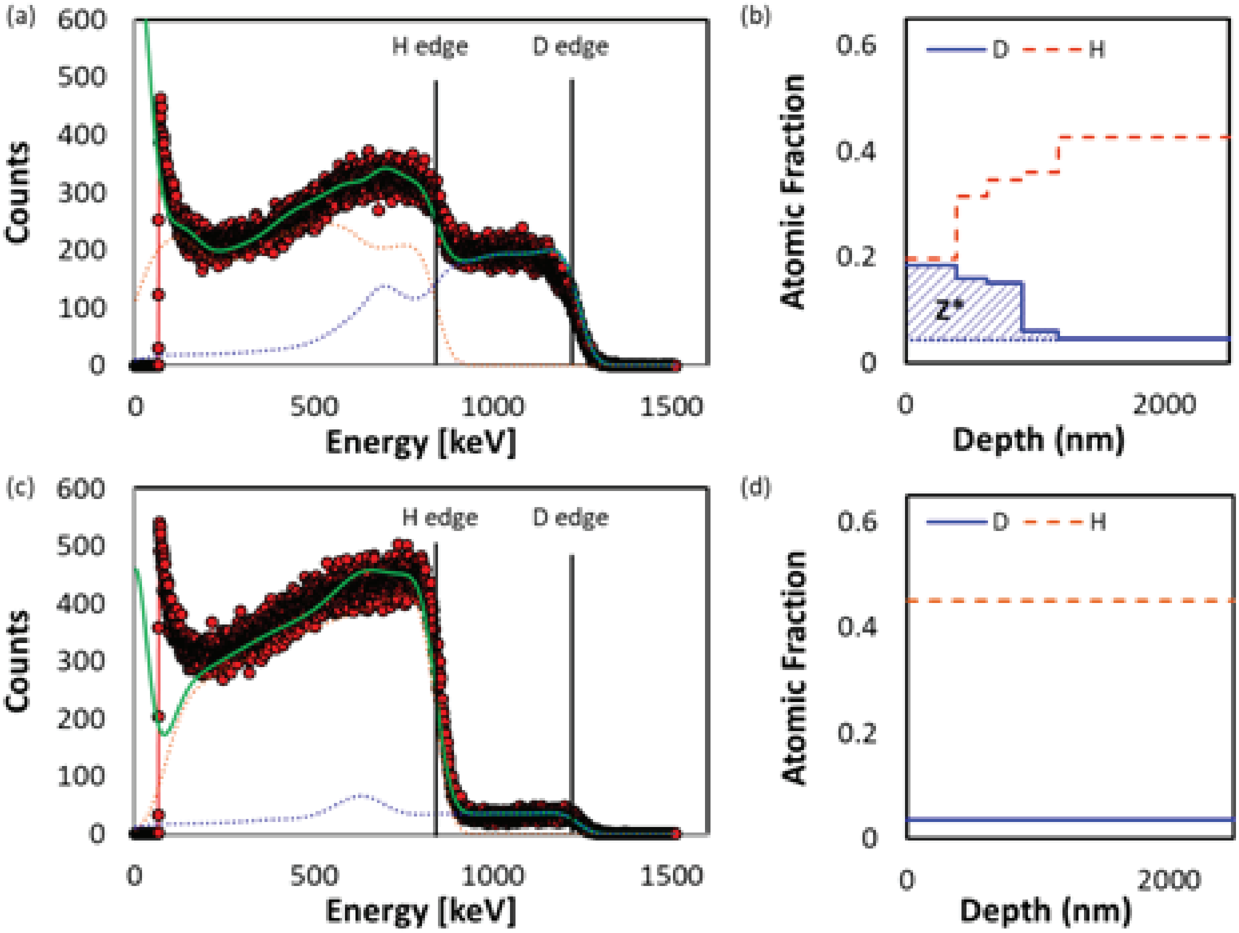


Figure 2. Analysis of ERD data using SIMNRA software. (a) Raw ERD data (particle counts versus energy) for a polymer/colloid sample with Pe = 25. The red circular symbols show the data, and the green continuous line shows the best fit with SIMNRA. Dotted blue and dotted orange lines show the individual fits for H and D respectively. (b) Depth profiles of deuterium (blue continuous line) and hydrogen (orange dashed line) obtained from (a). The shaded area shows the surface excess, z* of deuterium. (c) ERD data for a sample with Pe = 0.7 and (d) the corresponding depth profile, drawn in the same way as in (a) and (b), respectively. ©2020 MacroLetters, ACS

Introducing a new tool for deterministic Ion Implantation

Single Ion Implantation for Quantum Technologies

Silicon-based Quantum device manufacturing requires accurate placement of individual atoms with nanoscale precision, an extremely technically demanding task. Current successful methods include positioning individual atoms with a scanning tunneling microscope (STM), a slow process with very low yields.

Ionoptika, a leading ion beam specialist and member of RADIATE, has developed the Q-One instrument, a state-of-the-art tool for deterministic implantation of single ions into a target with nanoscale precision. The first of its kind, Q-One holds significant promise for Quantum device manufacture and advanced materials engineering at the nanoscale.

Q-One and SIMPLE

The first of the Q-One instruments was developed in collaboration between Ionoptika and the Surrey Ion Beam Centre at the University of Surrey, another member of RADIATE. The Surrey instrument, known as SIMPLE (Single Ion Multispecies Position at low energy), proved a success, quickly surpassing expectations. Following its success, Ionoptika built upon the SIMPLE platform and in 2019 launched the Q-One as a commercially available instrument, customisable to suit different applications and budgets.

SIMPLE was developed in conjunction with the group at Surrey to position single isolated donors sufficiently close to each other to enable interaction and so that their spin states might be read and manipulated. The original application was the placement of Group V donors in silicon; these are extremely promising candidates for applications within quantum technologies due to their long spin coherence lifetimes. However, in addition to Group V donors, there are many other ions of interest.

Development of the Ion Implantation Instrument

The Q-One instrument comprises a high vacuum implantation chamber with 20 nm focused ion beam; piezo-driven stage with 1 nm optical encoders; a high-resolution electron column providing detailed imaging down to 4 nm for in-situ verification and process control; proprietary software allowing microsecond pulse triggering and control; and one of two possible high-performance ion sources, either a liquid metal-type source (LMIG), or gas-based duoplasmatron source. A Wien filter on the column allows for mass separation, enabling the use of a wide range of liquid metal and liquid metal alloy ion sources.

Q-One offers a 20 nm spot size, however at such small spots, ion straggle can become a limiting factor. Straggle is inversely proportional to the ion mass, so heavy elements such as bismuth are now preferred as they significantly increase the chance of placing donors very close to one another. The large mass of bismuth is also reflected in its nuclear structure and very strong hyperfine interaction – much better for nuclear-spin based qubits.

Ion implantation provides access to many elements in the Periodic Table, which may open new areas of research such as exploring new donor elements that have not been previously considered due to technical constraints.

Deterministic Single Ion Implantation

Q-One works as a single ion implantation tool by harnessing low probabilities of ion implantation generated by extremely low beam current. Using high-speed pulsing and extremely low beam currents, the vast majority of pulses contain no ions whatsoever, and the chance of a double implant event is effectively reduced to zero – leaving only single ion implants. An array of high-sensitivity detectors constantly monitors for implant events, and once detected, stops pulsing and moves to the next location. The whole process takes just a fraction of a second.

With detection efficiencies already above 95% and still improving, failure rates are reduced significantly. Using Q-One, it is now possible to generate a perfect 9 x 9 array of implanted bismuth ions. With a range of new sources including Erbium, Praseodymium, and Manganese becoming available soon, we are excited to see the new discoveries this new tool will no doubt enable. Further information on the Q-One instrument is available at www.ionoptika.com.

Both SIMPLE 1 and SIMPLE 2 instruments are available for access through the RADIATE project from the Surrey Ion Beam Centre. For further information, visit www.ionbeamcentres.eu.

Street Art and IBA Science!

SAFIR has a new coat. Lady.K_156 (https://www.instagram.com/lady.k_156 - instagram account required to view the content), a well-known Parisian grapheuse has given the accelerator tank of SAFIR a fanciful makeover. But Lady.k_156 is no stranger to exploring the relationship between art and science, having also graphed works at the Orsay scientific campus in the south of Paris. Her work on SAFIR can be considered to be semi-vandal. To her Beaux Arts studies, she has now added the Rutherford cross section, Bohr stopping, and the Bragg rule for stopping powers! The Instagram video (https://www.instagram.com/p/Bz8FnTdl_oG/) of her first tag of SAFIR has garnered over 22000 views. From being the first electrostatic accelerator installed in a condensed matter physics laboratory, perhaps SAFIR can now lay the claim to being the first graphed Van de Graaff (or should we say, Van de Graph?).

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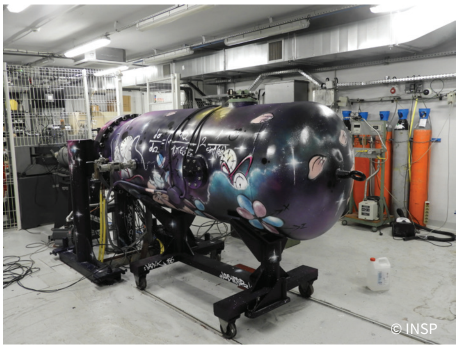

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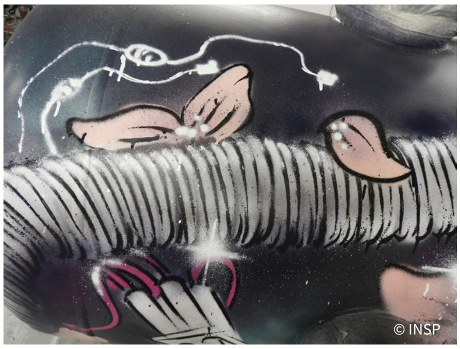

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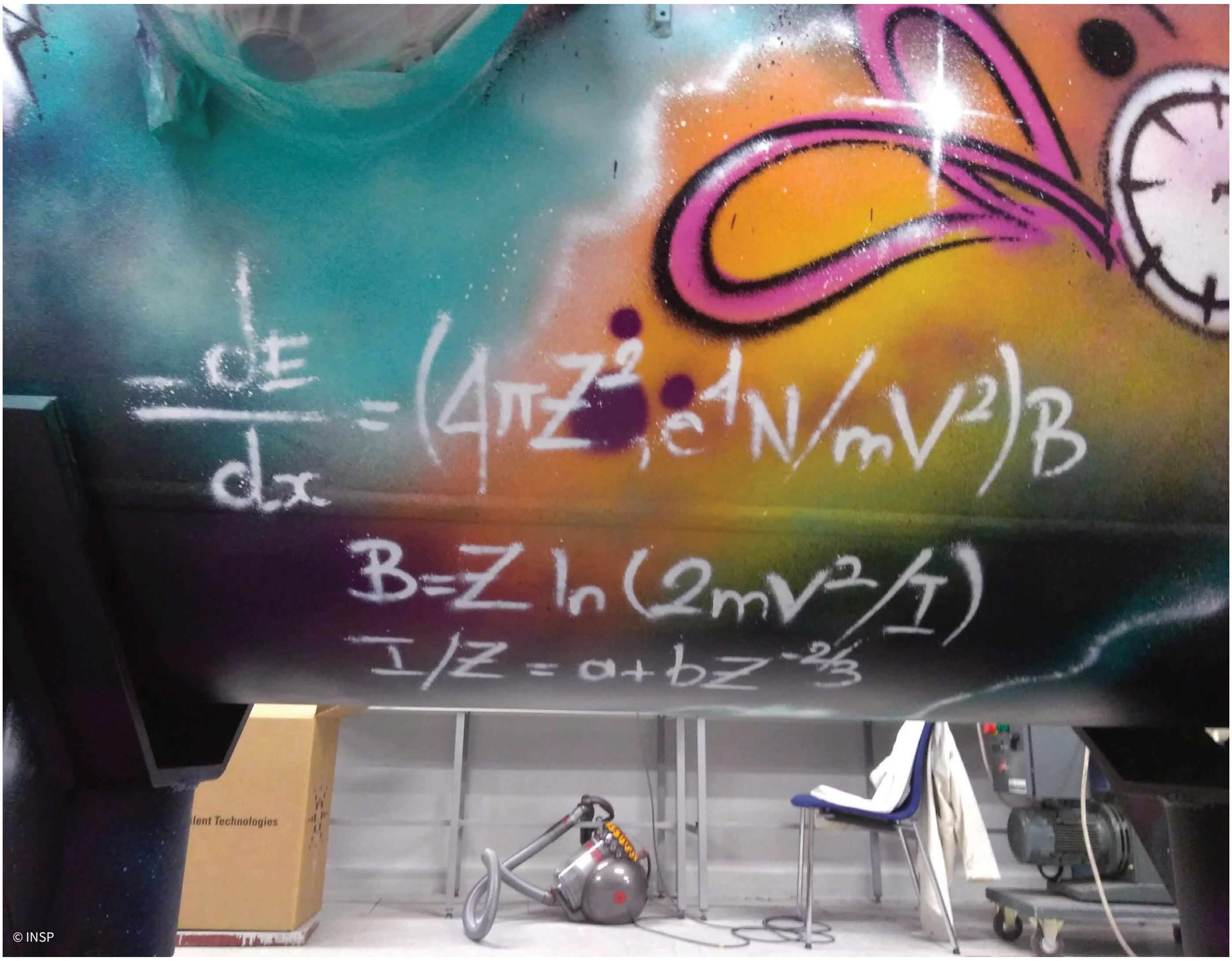

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Partner news: personnel

Goele Magchiels recently joined the Quantum Solid-state Physics section of KU Leuven (KUL) as a PhD student. Goele obtained her MSc in Physics from KUL, and continued for a PhD. Her research focuses on the real-time tracking of femtosecond laser-induced silicidation and germanidation by RBS, aiming to understand the reaction mechanisms occurring under these non-equilibrium conditions.
Within the RADIATE project, Goele will be working on artificial intelligence approaches to analyse a vast number of data sets and autonomously identify phase transitions. Simultaneously combining spectra form multiple setup geometries will be included to enhance the sensitivity of the ion beam analysis.

Masoud Dialameh joined the Ion Beam Analysis team of imec in 2020 as a researcher. Masoud obtained a PhD in Physics from KU Leuven and a PhD in Metrology from Politecnico di Torino. During his cotutelle PhD, he worked on the development of reference materials for Atom Probe Tomography (APT) and 3DToFSIMS. Masoud's interests include the characterization of pellicles and ultra-thin films using Rutherford Backscattering Spectrometry (RBS) and the development of a high-resolution RBS setup for applications in semiconductor industry. In his most recent work, he initiated a round robin experiment for quantification accuracy in APT.

Sandrina Fernandes has joined the SAFIR team for a year to work on the design of PIXE of soft X-rays and development of multi particle detector arrangements for RBS and NRA within RADIATE. After obtaining her PhD jointly at EPFL and CERN (Switzerland) on the development of nanostructured targets for production of rare isotope beams she went on to Michigan State University (USA) where she continued her work on studying the effects of heavy ion beams in graphite. Most recently she worked for three years at the Nuclear Research Institute of the Czech Academy of Sciences (Czechia) where she gained extensive experience in Ion Beam Analysis techniques and their application across numerous domains such as cultural heritage materials, biological systems, and materials for fusion technology. Welcome aboard Sandrina!

Other news

IAEA is pursuing the Long Term Sustainability of an MV Electrostatic Accelerator Facility

The success and reputation of an accelerator facility lies in a constant delivery of quality services to its multitude of users. In the competitive, challenging and ever-changing scenario of research funding and having to cater to a variety of stakeholders, the facility also needs to constantly balance many factors such as cutting-edge and excellent science, innovation, education, and societal impact. Such demands may require a novel vision of the leadership steering such a complex system. Traditional management models, which might have served well so far, may no longer prove be the most efficient.
The IAEA serves as a nodal point to link experts in the relevant field to managers of such facilities, to contribute to capacity building and enhance the capabilities of existing facilities for an optimum utilization of its resources. The IAEA Accelerator Knowledge Portal is one such resource dedicated to serve its mandate.
This main objective is to prepare a framework and guidelines to formulate strategies to ensure their long-term sustainability for MV electrostatic accelerator facilities by a proper integration of science, policy, and societal needs. It is meant to enable existing accelerator facilities to achieve an efficient, sustainable, a high standard of operation and explore their capabilities for new science and technologies. Enhance stakeholder engagement is visioned with various levels like government, users, industry, research executive agencies etc.
An IAEA technical meeting is to be organized in August 2021 in this field and we welcome your interest, suggestions and participation.
It is hoped that learnings from RADIATE's WP5 on Quality Assurance will help develop a toolset to aid other accelerator facilities to run a sustainable and scientifically relevant centre.
If interested, please contact: Aliz Simon (Aliz.simon@iaea.org) and Roger Webb, (r.webb@surrey.ac.uk).

Reaching for the Stars - ^{10}Be-Dating of Interstellar Events in a FeMn-Crust

by Dominik Koll, The Australian National University, Canberra, Australia

Reaching for the stars. One might think that you must travel far or use telescopes to achieve this goal. A more down-to-earth approach is to search for stellar traces in geological archives on our planet. The detection of long-lived ^{60}Fe ($t_{1/2}$ = 2.6 Myr) in a deep-sea ferromanganese crust by Accelerator Mass Spectrometry (AMS) is proof that Earth was impacted by the explosions of nearby massive stars. ^{60}Fe is an excellent tracer for stellar nucleosynthesis because of its non-abundance on Earth and the few production mechanisms involved to synthesise ^{60}Fe in space.

Another promising isotope to study astrophysical nucleosynthesis is the long-lived isotope ^{244}Pu ($t_{1/2}$ = 81 Myr). This nuclide is produced in rare stellar explosions or in neutron star mergers by the so-called rapid neutron-capture process (r-process). The detection of interstellar ^{244}Pu coincident with ^{60}Fe would shed light on the contribution of supernovae to the r-process nuclei abundance in the galaxy – still a mystery in nuclear astrophysics.

In the course of my PhD project, I am applying AMS to search for ^{60}Fe and ^{244}Pu in the largest deep-sea ferromanganese crust ever used in such a project. A crucial point of this project is to date the interstellar influx accurately in the crust over several million years, and to identify changes in the growth rates over time as well as variations in the growth rate across the surface of the crust. The most suitable method to date this geological archive is ^{10}Be dating ($t_{1/2}$ = 1.4 Myr) because of the high intrinsic ^{10}Be/^{9}Be ratio of 10^{-7} present in seawater, allowing dating over several half-lives of ^{10}Be.

RADIATE TA gave me the chance to get a hands-off ^{10}Be/^{9}Be measurement at Helmholtz-Zentrum Dresden-Rossendorf (HZDR). The obtained data (Figure 1) clearly indicate different growth patterns within one drill core of the crust (different growth with age) and between two drill cores (different growth over surface). A depth-age relation is obtained by the decay characteristics and the known ^{10}Be half-life as time-calibration. The growth rates of the deep-sea crust are 2 – 4 mm/Myr, depending on the drill core and depth, in perfect agreement with previous work.

Within this RADIATE project, we could also show the high accuracy of the AMS setup at HZDR by chemically processing and measuring four replicas in a subsequent beamtime. The samples were independently processed at HZDR and at the Australian National University with different initial sample masses and stable ^{9}Be addition to yield different ^{10}Be/^{9}Be ratios in the BeO to be measured. Both, the measurement and the chemistry at HZDR were performed under blind conditions and the result is displayed in Figure 2.

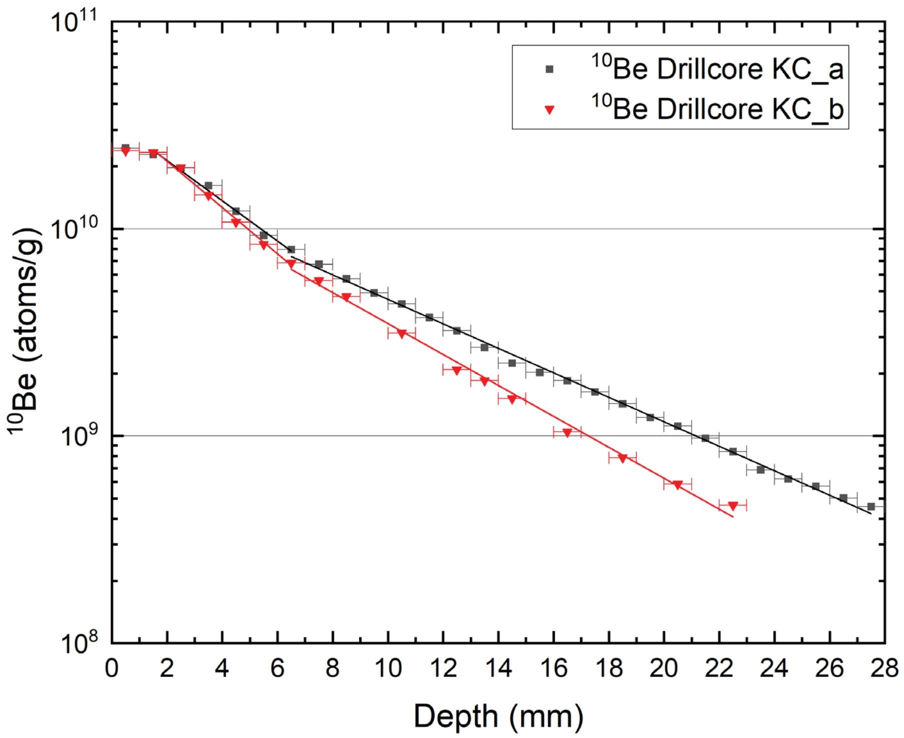


Figure 1: Depth profile of ^{10}Be concentrations in two drill cores (separated by 12.5 cm in distance). Differences in growth rates are visible from 7 mm to 28 mm through the significantly different decay curves of the ^{10}Be concentrations against depth. © D. Koll

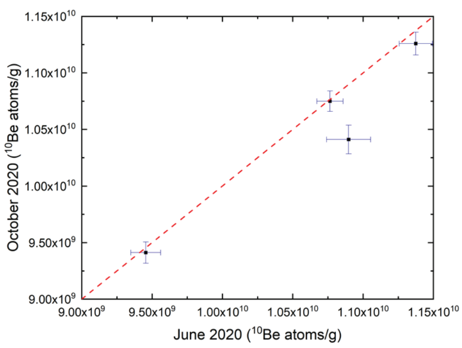


Figure 2: Comparison of independently prepared samples of KC_b in two beamtimes at HZDR. The data demonstrate high accuracy with the average data reproduced to better than 1% and a maximum deviation of 2.3% © D. Koll

The reproducibility is better than 1%, well explainable by the internal uncertainty from sample preparation and measurement statistics, with only one sample showing a deviation of 2.3% from the mean between the two beamtimes with an internal uncertainty of 1.4%. This level of accuracy is more than sufficient to date the individual drill cores with a time resolution of ±0.25 Myr (2 cm diameter, ^{60}Fe detection) and the individual layers of the crust with a time resolution of ±0.5 Myr (350 cm^2, ^{244}Pu detection), both limited by the variations in the intrinsic growth pattern and not by the dating method.

Summarizing, ^{10}Be dating of the ferromanganese crust at HZDR was very successful. Quality assurance showed high reproducibility and confirmed the capability of HZDR to perform accurate ^{10}Be measurements with high statistics and it also showed the robustness of the chemical procedure used to prepare the samples. I would like to thank RADIATE and the team at HZDR, explicitly J. Lachner, S. Merchel, G. Rugel and A. Wallner for the measurements, the sample preparation and the opportunity to work together on this exciting topic leading to this successful outcome.

Contact: dominik.koll@anu.edu.au

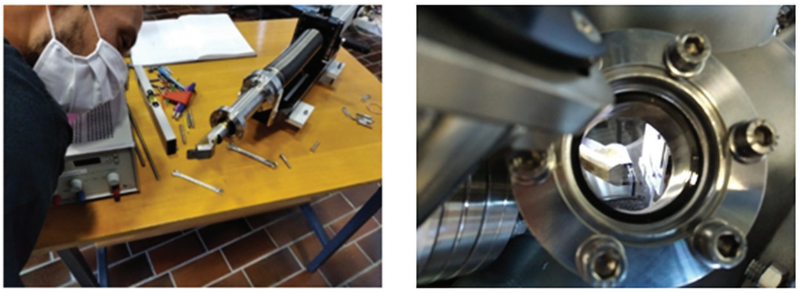
WP21 – Detectors and Electronics

Installation of a new XRF detector at Microanalytical Centre of JSI

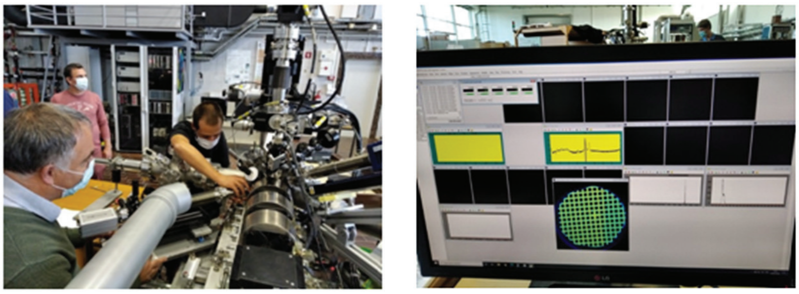
Microbeam station has been upgraded with a new and unique SDD detector which boasts four segments and will offer 1.1 steradian of solid angle. The detector will enable quantitative elemental analysis of organic and inorganic samples in dried or frozen-hydrated state at (sub) micron level. Thanks to its large solid angle we aim to accelerate measurements by a factor of 5.

The design of this detector was very demanding, as it was necessary to take into account the existing geometry of the measuring chamber with respect to the ion beam: the "head" of the detector had to be bent to 45°. Such a challenge was taken over by the company PNDetector and the purchase of the detector was partly financed by the Public Agency for Research of the Republic of Slovenia (Public tender for co-financing the purchase of research equipment; Package 17).

Beside PNDetector specialists, the team that worked on installation consisted of Dr Primož Pelicon, Mitja Kelemen, Dr Paula Pongrac, Dr Matjaž Vencelj and Mirko Ribič.



The detector outside the chamber (left) and the "head" of the detector is bent to 45° to fit into the existing chamber (right) Photos: © JSI



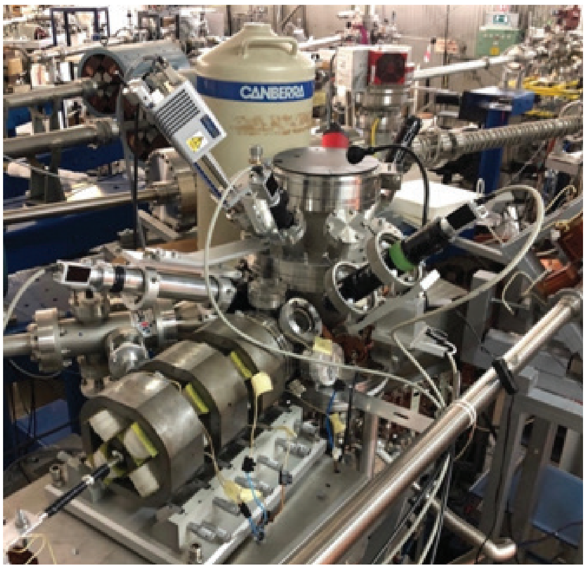
Installation process (left) and the first test measurements (right) Photos: © JSI

JRA1 - Ion sources and beams, Microbeam Optics

A new microprobe beam line at RBI, by Milko Jakšić, RBI, Zagreb

After several years of development, a new (second) microprobe focusing system and associated scattering chamber become operational at RBI. It reached a new milestone in terms of microbeam spot size with only 270 nm resolution obtained for a low current 2.7 MeV carbon ion beam. This is in line with expectations for this task, to satisfy the increasing users demand for heavy ion beams with small spot sizes. Developments in the laboratories of three RADIATE partners (RBI, JSI and ATOMKI) are planned in order to reach spot sizes around 100 nm and below 1000 nm for low- and high-intensity ion beams, respectively.

The new RBI microprobe system is based on the low cost, in house designed quadrupoles, connected into the high excitation triplet. This system can accept ion beams from the 1.0 MV Tandetron accelerator. Scattering chamber consists of the two focus plains (short and long). The short focus has only 7 cm working distance, which is the same as the single quadrupole length. It is used for the low current, high resolution applications (e.g. STIM and IBIC) that can be performed in a small prechamber. The long focus is at 26 cm working distance, positioned in the centre of the main scattering chamber, which is currently equipped with SDD x-ray detector for PIXE, large solid angle Ge detector for PIGE and conventional silicon solid state detector for EBS and off-axis STIM. The unique feature of this chamber is its capability to accept not just microbeam from the 1.0 MV tandem, but also simultaneously a collimated ion beam from the second RBI accelerator, the 6.0 MV Tandem van de Graaff. Electrostatic focussing system, for this second beam, will be commissioned during 2021 making this new RBI microprobe first dual beam microprobe in the world.



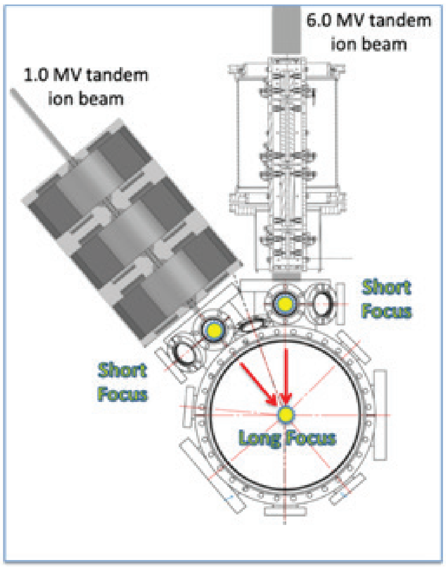


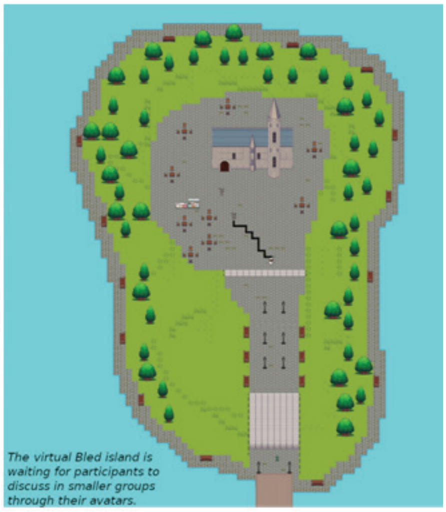
Photo (left) and diagram (right) of the new microprobe focusing system and associated scattering chamber © RBI

17th ICNMTA - International Conference on Nuclear Microprobe Technology and Applications

By Andrej Košiček

Due to the pandemic situation around the world, the 17th ICNMTA 2020, which was supposed to take place in Bled, Slovenia, was held on-line on September 14 and 15, 2020, organized by JSI – department of low and medium energy physics (F2). The conference attracted 151 attendees from 29 countries and six continents. Recent technical advancements and the broad spectrum of focused ion beam applications were presented in 21 invited talks, 26 contributed talks and 20 posters. All the talks are recorded and available at the conference web site (https://www.icnmta2020.org/ParticipantPanel) with the participant password until the next ICNMTA conference. Despite initial doubts about the effectiveness of virtual implementation, participants ultimately agreed that the conference was very useful and necessary to keep laboratories around the world informed about the progress in the field. Impressive work was presented on biomedical applications using focused ion beams to make novel microfluidic devices and luminescent sensors. There were a lot of innovations in the applications of single ion techniques from quantum technologies to radiobiological studies.

We express again our gratitude to sponsors for their essential support of the conference and we are looking forward to meeting you at the 18th ICNMTA conference (ICNMTA2022), which is planned for September 2022 in Slovenia, in person.



Virtual Bled island © ICNMTA

Technology Transfer Workshop: Industrial Applications of Ion Beam Technologies

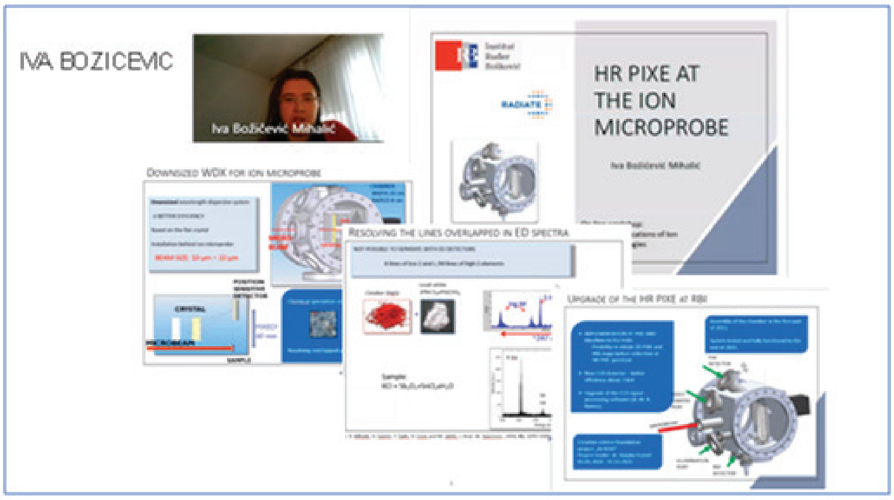
by Johan Meersschaut

To provide tailored access of the ion beam technology to industrial customers, the RADIATE consortium supports three of its partners with the appointment of a dedicated Innovation Manager. The Innovation Managers support the transfer process along the whole value chain – including scouting, evaluation, exploitation planning, and acquisition of funds for validation, identification of appropriate partners as well as contract negotiations. The technology transfer workshop was an initiative to support the successful installation and training of the newly installed Innovation Managers.

The workshop has been held on-line on December 3rd, 2020. During this workshop, the newly hired as well as experienced Innovation Managers did report on their activities. In addition, the commercial enterprises participating in RADIATE (CAEN, IONOPTIKA, Ionplus, and Orsay Physics) have presented their view of industrial applications of ion beam technology. Also, imec has presented its view on how to deal with large international companies. Before closure, the workshop hosted a discussion round on foresight and industrial needs in the next decade.

The workshop on Industrial applications of Ion Beam Technologies has attracted more than 50 participants form numerous institutes in Europe. We have received the feedback that many people have enjoyed the application-oriented approach of the selected presentation. We show in figure 1 a few snapshots of slides and the presenter view during one of the presentations.

A book of short abstracts containing the list of participants was distributed to the registered participants.



Snapshots taken during the presentation given by Iva Bozicevic (RBI) at the RADIATE Technology Transfer Workshop © J. Meersschaut

RADIATE Summer Schools

The next RADIATE Summer School, which was postponed from 2020, will be taking place virtually between the 28-30th April 2021. More details to be published on the RADIATE website soon - https://www.ionbeamcenters.eu.

IAEA Training workshop: "The second quantum revolution: new roles for accelerators and ion beams"

Virtual event, 4-7 May 2021, Vienna Austria

Ion beam techniques (IBT), have been extensively applied for material analysis and modification by using ions in the keV-GeV energy range especially for electronic materials and devices and in the semiconductor industry. Actually, the knowledge and expertise gained over the last decades in the development of new methodologies for single ion implantation and detection, conjugated with recent advances in ion beam material analysis and modification at the nano-scale, envisage a potential high impact of IBT even in recently emerging quantum technologies.

The Training Workshop will provide knowledge transfer to accelerator physicists on the new techniques to tune material properties for "a new technological era"; on the other hand material scientists would learn about the potential of ion beams to engineer new materials.

Key topics will include:

- The overview of theory of radiation effects in materials and modelling of dynamics of vacancies and interstitials in collision cascades using molecular dynamics tools;

- Novel ion beams techniques for materials characterisation and modification using keV to GeV ions;

- Examples on how to tune/predict materials properties and create engineered structures by ion beams.

For further details please check the IAEA Accelerator Knowledge Portal https://nucleus.iaea.org/sites/accelerators/Pages/default.aspx around end of February 2021 and/or contact: Aliz.Simon@iaea.org

IAEA Online Training Course

Introduction to electrostatic accelerators: from basic principles to operation and maintenance (iaea.org)

This e-learning course presents an aid for personnel wanting to increase their knowledge on operation and maintenance of low energy electrostatic ion accelerators and associated infrastructure. The learning objective is to provide introductory and background theoretical and practical information for the effective and safe operation and maintenance of accelerators, ion sources, plant and equipment as well as operational procedures. The course consists of five parts:

- The electrostatic accelerator
- Ion sources
- Beam transport
- Vacuum
- Safety considerations

The course is recommended for students, laboratory staff, and users of these facilities. Newcomers in the field will get the most of it.

For feedback and additional details please contact Natko Skukan: N.Skukan@iaea.org

Glimpse into the IAEA Accelerator programme

The International Atomic Energy Agency (IAEA) Accelerator Knowledge Portal is a resource created for and by the accelerator community to enable exchange of information between scientists, industrial partners and policy-makers. The Portal contains information about accelerators worldwide which are used not only for research but also for industrial and medical purposes.

Upcoming Events

Conferences

- 29th International Conference on Atomic Collisions in Solids (ICACS) and 11th Symposium on Swift Heavy Ions in Mater (SHIM) is was supposed to be held in Helsinki, Finland in June 2021 (postponed from 2020), but will now take place from from 19 June to 24 June 2022
  See https://www.helsinki.fi/en/conferences/icacs-shim-2020

- 22nd Ion Beam Modification of Materials Conference (IBMM) to be held in Lisbon, Portugal (postponed from 2020). The website says it will be held in 2021 but rumours say it will be postponed until 2022 see: http://www.ctn.tecnico.ulisboa.pt/IBMM-2020/

- 15th Conference on Computer Simulation of Radiation Effects in Solids (COSIRES) to be held in Porquerolles, France (postponed from 2020). Will now take place in 2022 see https://sites.google.com/view/cosires2020/home - it is possible that a small virtual meeting may take place this year.

- 17th International Conference on Nuclear Microprobe Technology and Applications (ICNMTA) was held virtually in 2020, the "live" meeting being postponed until 2022, to be held in Bled, Slovenia. See https://www.icnmta2020.org/

- 25th International Conference on Ion Surface Interactions (ISI-2021) to be held in Yaroslavl, Russia, is planned as "hybrid" conference, with local and remote attendees. 23-27 August 2021. See http://project3329204.tilda.ws/con

- 23rd International Conference on Secondary Ion Mass Spectrometry (SIMS23) is still planed to take place in Minneapolis, USA from 26th September 1st October 2021. See https://sims23.avs.org/

- Spring eMRS meeting 31st May – 4th June 2021 will be held virtually
  See https://www.european-mrs.com/meetings/2021-spring-meeting-0

- Spring MRS meeting 18th-23rd April 2021 will be held virtually.
  See https://www.mrs.org/meetings-events/spring-meetings-exhibits/2021-mrs-spring-meeting

- 25th International Conference on Ion Beam Analysis (IBA-2021) & 17th International Conference on Particle Induced X-ray Emission (PIXE2021) are still planned to take place in Toyama, Japan from 9-15th October 2021. See https://ion-beam.jp/iba2021/

- 23rd International Conference on Ion Implantation Technology (IIT) (postponed from 2020) is planned to take place 12th-16th September 2021 in San Diego, USA. See https://www.mrs.org/iit2021

- 26th Conference on Applications of Accelerators in Research and Industry (CAARI) & the 52nd Symposium of North Eastern Accelerator Personnel (SNEAP) scheduled to take place in Las Vegas in August 2020 has been postponed until further notice.
  See https://caari-sneap.com/

- 4th International Conference on Radiation and Emission in Materials (ICREM-4) is planned to run 14-17th December 2021 in Thailand. No web site available yet.

Sign up for the RADIATE newsletter here:
https://www.ionbeamcenters.eu/radiate/radiate-newsletter/

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