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RAPID, SEMI-QUANTITATIVE ELEMENTAL DEPTH PROFILING USING PLASMA TIME-OF-FLIGHT MASS SPECTROMETRY

Introduction

Plasma Profiling Time-Of-Flight Mass Spectrometry (PP-TOFMS) is a novel elemental depth profiling technique developed by Horiba Scientific. It couples an argon plasma source for sample sputtering and ionization with an orthogonal time-of-flight mass spectrometer. The technique delivers **nanometer-scale depth profiles with high sensitivity** and is capable of providing **calibration-free semi-quantitative results**. Moreover, the operation of the instrument is **simpler and faster compared to typical SIMS instruments** requiring only a few minutes including sample introduction and pumping.

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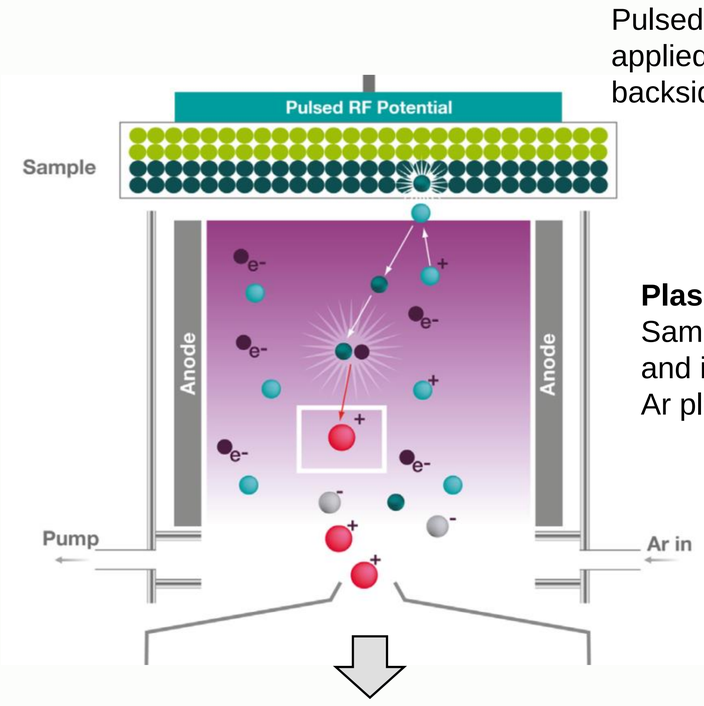
The PP-TOF-MS technique



Pulsed RF power is applied on sample's backside

Plasma source
Sample sputtering and ionization using Ar plasma

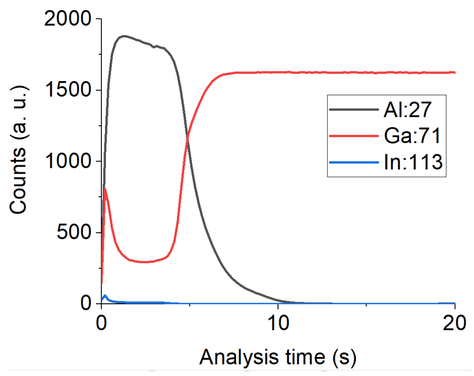
Source pressure of 100–200 Pa -> quick operation after sample introduction

To TOF mass spectrometer
30 kHz mass spectra acquisition

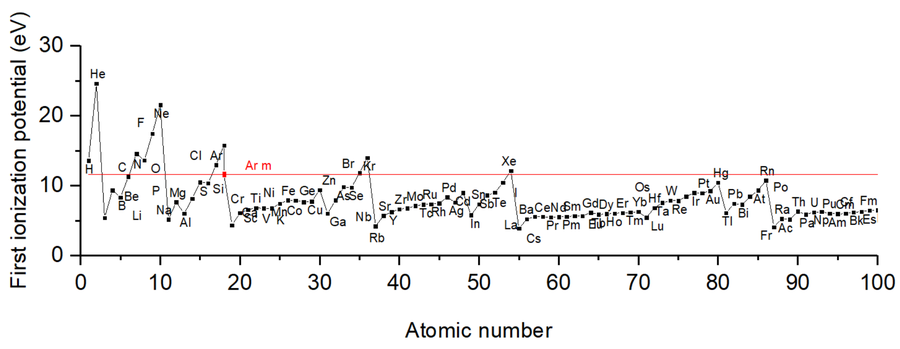
The Ion Beam Ratio method

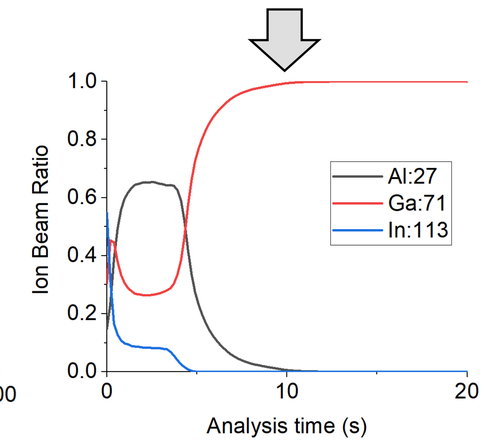
Semi-quantification is obtained from the ratio of ion signals corrected for isotopic abundance[1].

$$IBR_{ion(t)} = \frac{I_{ion(t)}}{ab_{ion}} \Big/ \sum_{ions} \frac{I_{ion(t)}}{ab_{ion}}, \qquad \sum_{ions} IBR_{ion}(t) = 1$$



Works well with elements with 1st ionization energy inferior to 11.5 eV.

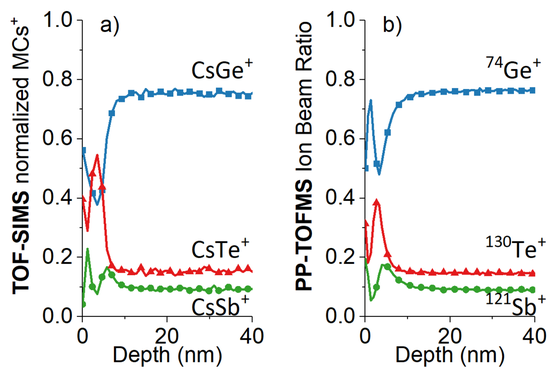


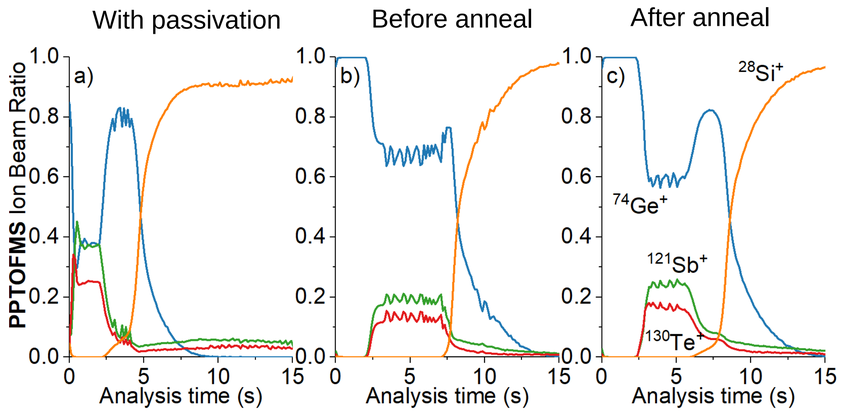


Applications

GeSbTe for memory applications

PP-TOF-MS IBR method has shown very good agreement with calibrated TOF-SIMS measurements while being much faster (3 mins/sample including introduction and pumping). The technique achieves nm scale depth resolution.

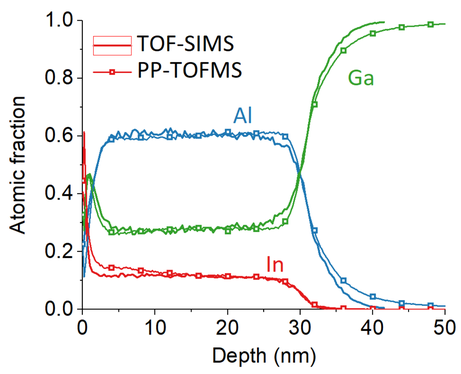




The technique was extensively used to support the material development[2], in particular to study the effect of passivation layers to maintain a Ge-rich composition after annealing.
PP-TOF-MS depth profiles of GeSbTe thin layers: after annealing without passivation layer (a), with the passivation layer before (b) and after (c) annealing.

InAlN barrier layers engineering for power applications

Due to their outstanding properties, III-nitride materials based on GaN, AlN, InN and their compounds are increasingly being used in the manufacture of high-power and optoelectronics components.



IBR and calibrated TOF-SIMS measurements show very good agreement[3].
The technique proved to be very useful in the development of high quality ternary and quaternary alloys. PP-TOF-MS fast turnaround time was helpful as many process parameters need to be optimized. An example where PP-TOF-MS enabled the rapid optimisation of showerhead reactor condtions to minimize Ga content in InAlN films was published recently [4, 5].

References

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