Electron, Ion and Photon Beams in a New Analytical and Prototyping Instrument

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Rapid advances in nanotechnology and nanofabrication are a cause of growing needs for nano-scale prototyping, imaging, modification and manipulation in a single universal instrument. Wide variety of techniques integrated in a single tool gives multiple advantages, especially the possibility to fabricate, analyze and correlate in-situ. A multifunctional tool comprising SEM, FIB, SPM, TOF-SIMS, EDX and EBSD has been presented recently.[1]

Following, a photon beam is added to the system, thus electron, ion and photon beams in a single instrument are present. The Confocal Raman Microscope (CRM) is integrated, yielding valuable chemical information on top of the high resolution SEM image, nano-prototyping by FIB and all other methods.

Until now, systems offering Raman measurements in-situ with SEM usually supported only point spectral measurements and the resolution did not exceed 2-5 μm. When just a single spectrum is acquired, one can never be sure whether the position calibration is off. In our system, full optical microscope column capable of mapping is used. Its confocal setup provides resolution of 360 nm which has been possible only in stand-alone instruments so far. SEM column[2] is optimized for low accelerating voltages and gives resolution of 1 nm at 15 kV and 1.4 nm at 1 kV. SEM image and CRM spectral map of the same sample area are acquired in-situ and a precise overlay is created, see a lithography lift-off example in Figure 1. The mapping is realized via CRM objective lens scanning and, therefore, it is independent of sample stage position or sample mass. The vertical movement of the CRM objective is also supported, which in combination with confocality of the system allows non-destructive 3D tomography for laser transparent samples. The in-situ setup with mapping is greatly beneficial since one can always find the same region of interest with both mentioned techniques.

Nanofabrication and prototyping capability is ensured by FIB. Ion beam also gives a basis for various 3D tomography techniques. E-beam lithography benefits from ultra-fast scanning with pixel dwell time down to 20 ns. A specialized DrawBeam software provides CAD-like GUI for both E-beam lithography and FIB nanofabrication.[3]

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[1] J. Jiruše et al, Combined SEM-FIB-TOF-EDX-EBSD as a Multifunctional Tool. Microsc. Microanal. 18 (Suppl. 2), 638-639 (2012).

[2] J. Jiruše, M. Havelka, J. Polster and F. Lopour, New Ultra-High Resolution SEM for Imaging by Low Energy Electrons. Microsc. Microanal. 19 (Suppl. 2), 1302-1303 (2013).

[3] The research leading to these results has received funding from the European Union Seventh Framework Program [FP7/2007-2013] under grant agreement n°280566, project UnivSEM.

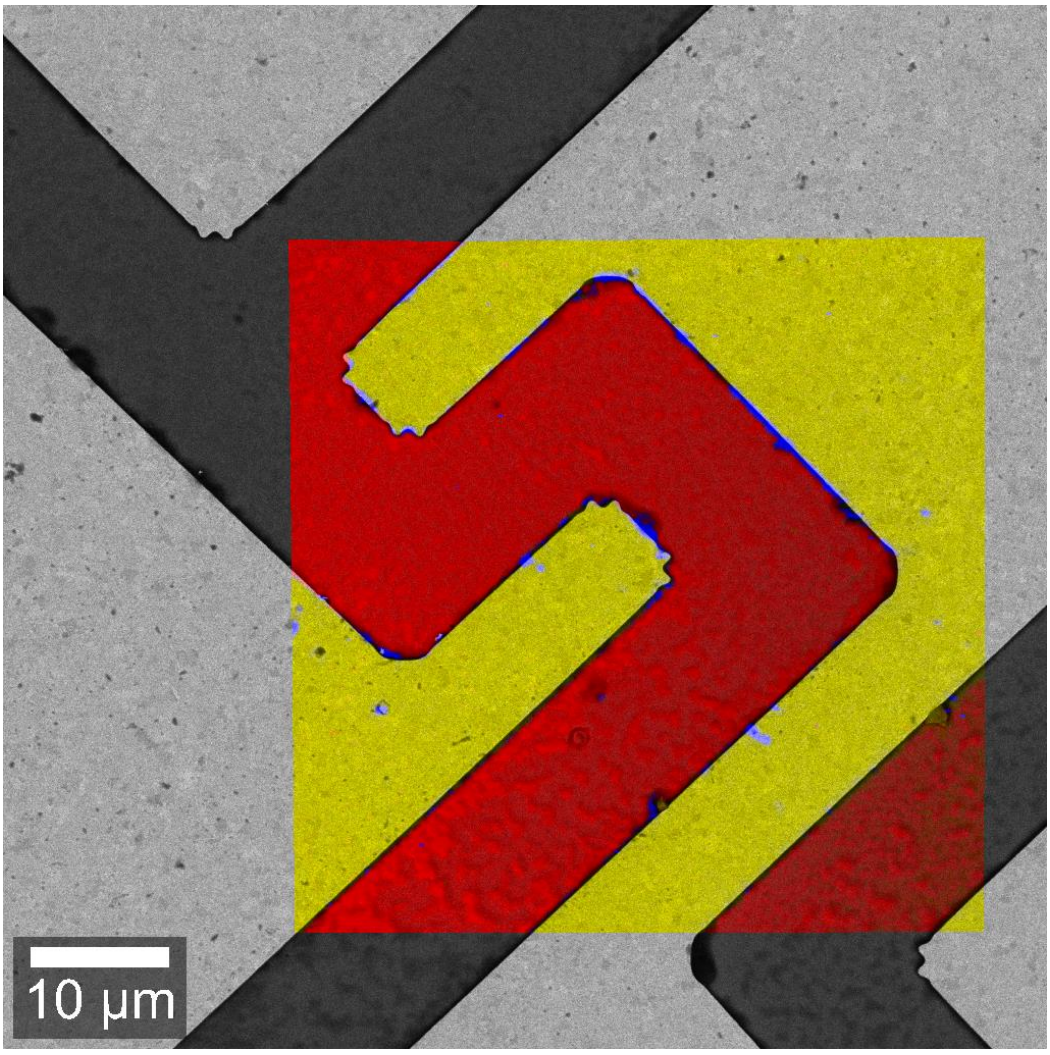

Figure 1: Overlayed SEM (in grey) and Raman (in color) micrographs of low temperature GaAs. The yellow, red and blue areas denote gold, GaAs and polymer residuals from the lithography lift-off process, respectively.