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Focused Ion Beam (FIB) – TEM: Exploring Earth Materials with Ions and Electrons

Richard WIRTH*

Helmholtz-Zentrum Potsdam, Deutsches GeoForschungsZentrum GFZ, Sektion 3.3, Chemie und Physik der Geomaterialien

Focused ion beam techniques have been applied in Geosciences since 10–15 years. The basic principal of FIB is using accelerated Ga-ions to sputter material from a target. At the beginning of FIB application in Geosciences it was utilized as a tool to prepare site-specific samples for transmission electron microscopy (TEM). FIB enabled sputtering electron transparent foils with typical dimensions $15 \times 10 \times 0.150 \mu\text{m}$ from precisely that location we are interested in. That capability increased the demand of TEM use in Geosciences substantially. Meanwhile, the availability of so called DualBeam™ devices, which are operating an ion column simultaneously with an electron column (FIB-SEM), has widened the application of FIB technique substantially. DualBeam™ machines are used not only for TEM sample preparation but also as micromachining tools, for orientation contrast imaging, 3D imaging, 3D cross sectioning, 3D EBSD and 3D EDS analysis. The

combination of ion and electron techniques generated major progress in micro- and nano-structural analyses in Geosciences. Site-specific foils prepared from any material in Geosciences - from diamond to sedimentary rocks and to materials in Geobiology - cannot only be used for TEM investigations but also for Synchrotron FTIR, Brioullin spectroscopy, NanoSIMS and X-Ray microscopy investigations. Examples of different FIB-TEM applications in Geosciences are presented: nano-inclusions in diamond, EBSD on microcrystalline diamond (carbonado), 3D imaging of unusual grain boundaries in marble, nano-porosity in gas shale, distribution and behaviour of organic material in sediments, natural composite materials in a deep sea sponge (monorhaphiscuni) and Paleoproterozoic phosphogenesis in the 2 Ga years old Zaonega Formation.

* Corresponding author. E-mail: wirth@gfz-potsdam.de