Determination of the physical properties of single helium nanobubbles in various materials using spectrum imaging.

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Helium nanoscale bubbles can be formed in a wide variety of materials following the aggregation of vacancies and helium atoms introduced in high concentration. They are an important class of defects in solid state materials that are both of technological and fundamental relevance as they can modify the physical and mechanical properties of materials.

The physical parameters of the bubbles (helium density, associated pressure, size, morphology) are the cornerstone to fully describe their formation and evolution mechanisms. Spatially-resolved EELS in STEM has been shown to be a powerful tool to determine these parameters, in particular in metals.

Here we show that not only STEM-EELS but also Energy Filtered TEM spectrum imaging can be used to determine the physical parameters of the bubbles in various semiconductors matrices such as Si, Ge, GaN but also in ceramics such as SiC and in minerals (euxenite). We detail the acquisition parameters that we have optimized, the method itself and its limitations inherent to signal processing. Besides, we show that the EFTEM approach allows for overcoming one of the STEM-EELS detrimental issues: helium detrapping under the electron beam. Moreover, it allows for determining the helium density in a large set of bubbles at a time.