Synchrotron Analysis Focus Topic
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Synchrotron Analysis Poster Session

SA-TuP1 Mesoscale and Microstructural Changes in HMX Measured with Synchrotron-Based USAXS and Microtomography, ***T.M. Willey***, *L. Lauderbach*, *T.W. van Buuren*, *I.C. Tran*, Lawrence Livermore National Laboratory, *J. Ilavsky*, Argonne National Laboratory, *H.K. Springer*, Lawrence Livermore National Laboratory

HMX (octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine) is a relatively insensitive high explosive at room temperature. Mesoscale voids are thought to influence sensitivity and detonation properties in polymer bound explosive compositions, where HMX crystals are mixed with, for example, ~5% Viton. HMX molecular crystals undergo a solid-solid phase transition from the so-called beta- to delta- phases at elevated temperatures around 170 Celsius, an prior to this study, little was known about how this phase transition affected mesoscale voids and microstructure. We have measured the ultra-small angle x-ray scattering (USAXS) as the explosive was heated through this phase transition. The USAXS is sensitive to structure from about 10 nm to about 5, and shows how the porosity in these size regimes evolves during the phase change. X-ray computed microtomography was also performed before and after temperature cycling to observe changes on length scales larger than a micron. These results enable studies to determine how the mesocale porosity affects detonation properties in heated HMX-based explosives.

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SA-TuP4 Grazing Incidence X-ray Fluorescence Analysis for the Characterization of $Ge_{1-x}Sn_x$ Thin Films, ***P. Hönicke***, Physikalisch-Technische Bundesanstalt, Germany, *C. Fleischmann*, IMEC, Belgium, *P. Hermann*, Physikalisch-Technische Bundesanstalt, Germany, *S. Zaima*, Nagoya University, Japan, *B. Beckhoff*, Physikalisch-Technische Bundesanstalt, Germany, *O. Nakatsuka*, Nagoya University, Japan

Crystalline GeSn alloys have triggered enormous research efforts in the last decade for future optoelectronic devices. The $Ge_{1-x}Sn_x$ material system exhibits a tunable direct energy gap in the composition range $0 < x < 0.15$, enabling its use in light emitting/absorbing components. In addition, GeSn alloys are predicted to show enhanced carrier mobility when compared to elemental Ge, a necessary prerequisite for high-speed semiconductor devices.

The growth of single crystalline GeSn thin films is very challenging due to the limited solubility of Sn in Ge and the large lattice mismatch. Progresses made in the last years using epitaxial growth techniques such as molecular beam epitaxy (MBE), GeSn thin films can be grown with high crystal quality and Sn concentrations above 1 at.% [1]. However, as these films are highly metastable with respect to their equilibrium conditions, sustaining their quality, and hence their electrical and optical properties upon further processing will be as demanding as their growth. As such, the applicability of GeSn in electronic devices will depend on their stability upon e.g. thermal treatment.

We report on the thermal stability of strained GeSn (4-6 at.% Sn) thin films grown by low-temperature MBE on Ge. We discuss degradation mechanisms observed in these layers and the thermal budget that can be derived from this. The samples were characterized using synchrotron-based, reference-free X-ray fluorescence analysis [2] in grazing incidence mode (GIXRF). This technique is based on the in-depth intensity variations within the X-ray Standing Wave (XSW) field which arises between primary and reflected beam. During a GIXRF measurement, the depth distribution of Sn is combined with the intensity distribution of the XSW field, resulting in a distribution specific angular fluorescence curve [3]. This method enables us to gain information about the *in depth* and the *integral changes* of the Sn concentration in the layer.

A relative comparison of GIXRF profiles recorded on pristine and annealed GeSn indicates significant diffusion of Sn and compositional changes in the GeSn layer for high annealing temperatures. Complementary analysis reveal morphological changes on the surface of the annealed films, e.g. the formation of large islands. IR-based scattering type scanning-near-field optical microscopy (s-SNOM) [4] measurements show that these islands exhibit distinctively different optical properties than the GeSn layer.

[1] Shimura et al., Thin Solid Films **518** 2010

[2] Beckhoff et al., Anal. Chem. **79**, 7873 2007

[3] Hönicke et al., Anal. Bioanal. Chem. **396**, 2825 2010

[4] Hermann et al., Optics Express **21**, 2913 2013

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