PROPERTIES OF HgTe NANO-DOTS EMBEDDED IN PbTe MATRIX PRODUCED BY PRECIPITATION TECHNIQUE

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Owing to the technological importance of semiconductor quantum dots (QDs) in the advanced electronic devices, several techniques have been proposed to fabricate ideal nanostructures. Among them, self-assembly of three-dimensional islands in strained epitaxial films via Stranski-Krastanow (S-K) growth mode [1] provides a promising route to the realization of defect-free QDs. Due to the rigorous nature of this process and the limitation to the highly mismatched system such as Si-Ge [2], however, the three dimensionally distributed nano-dots within the barrier matrices are extremely difficult to fabricate. As an alternative for the fabrication of defect-free, three dimensionally distributed nano-dots, the present authors have reported a simple and reliable technique based on the precipitation phenomena [3]. This enables the fabrication of well defined nanostructures comprising disc shaped HgTe nanocrystallites and surrounding PbTe matrix using three-step heat treatment process- solid solution, quenching and aging. In this technique, the control of precipitate formation has become an object to be exploited rather than one to be avoided, as it used to be.

In this presentation, we propose the precipitation of disordered HgTe embryos and the subsequent volume expansion as direct causes for the formation of HgTe nano-disc. To evidence such an effect, Raman spectroscopy is used under the fact that disordered HgTe structure should take an expanded volume compared with that of ordered HgTe due to the increased vibrational state in the disordered structure [4]. Here, initial disordering and subsequent volume expansion in HgTe nanocrystallites are discussed using the analyses of characteristic HgTe Raman frequencies shifts. Also, based on the experimental confirmation that there exists perfect coherency between HgTe nano-disc and PbTe matrix, a simple linear elasticity explaining the strain relation around a stress relaxed nano-disc is considered with the defined 'disorder-induced tetragonality' representing the phenomenon of tetragonal unit cells formation in a coherent HgTe disc. Combined with the actual sizes of tetragonal unit cells within HgTe nano-discs obtained from high-resolution transmission electron microscopy (HRTEM), the initial lattice mismatch caused by the formation of the disordered HgTe precipitates is calculated.

References:

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3. M. Lee and C. -U Kim, Physica **B304**, 267 (2001).
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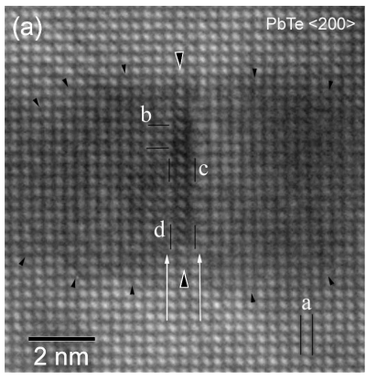

Fig. 1. The micrographs showing typical <001> HRTEM images of HgTe nano-disc in the PbTe-2.5 mol.% HgTe alloy aged for 5 at 300°C. Notice that HgTe nano-disc is aligned parallel to the beam direction.

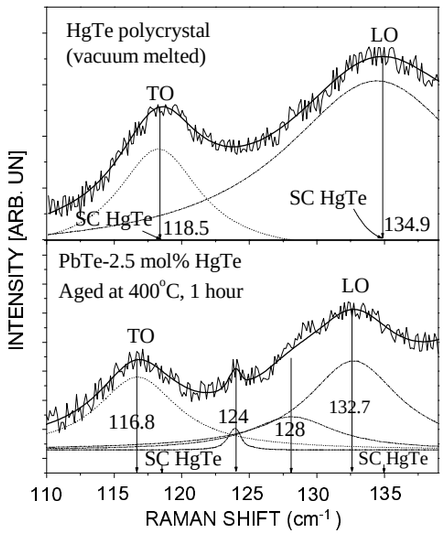

Fig. 2. The characteristic Raman shifts of HgTe in various conditions where (a) is for HgTe ploycrystals, (b) for HgTe nanocrystallites aged for 1 hour at 300 °C, respectively. The reported values for the single crystalline (SC) HgTe are also showed for comparison.

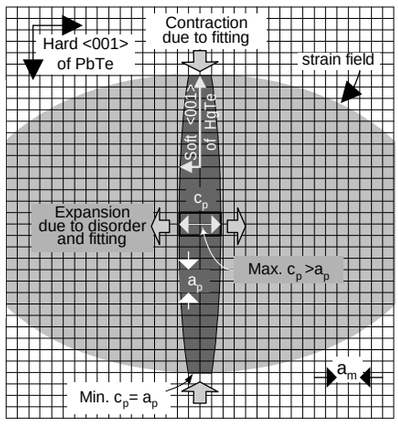

Fig. 3. The schematic diagram showing the phenomenon of the disorder-induced tetragonality in the stress relaxed nanostructure.