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Micropositioning and tilting systems based on thermoelectric actuation

Dirk C. Meyer,[a] Peter Gawlitza,[a] Kurt Richter,[a] Klaus-Dieter Schulze,[b] Reinhard Sprungk[b] and Peter Paufler[a]*

[a]Institut für Kristallographie und Festkörperphysik, Fachrichtung Physik der TU Dresden, D-01062 Dresden, Germany, and [b]Bereich Technik, Fachrichtung Physik der TU Dresden, D-01062 Dresden, Germany. E-mail: paufler@physik.tu-dresden.de

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An inexpensive system for micropositioning and tilting based on thermoelectric actuation is described; it has comparable position resolution and stiffness to usual systems based on piezoelectric actuation.

Keywords: micropositioning; tilting; thermoelectric actuation.

1. Introduction

Systems for micropositioning and tilting (to ~1 μm or 0.001°, respectively) are usually based on piezoelectric actuation. These systems are indispensable for high dynamic applications (fast positioning). For slower movements (~0.1 μm s^{-1}) we have developed a very low cost system based on thermoelectric actuation that has comparable position resolution and stiffness (Meyer, 1995; Meyer *et al.*, 1996). Heating and/or cooling of the actuator is performed by a Peltier element. For accurate operation, one side of the Peltier element must be thermally stabilized, *i.e.* held at a preset or known temperature.

The prototype of such a micropositioning system provides a maximum transit of 15 μm with a resolution better than 0.1 μm (limited by the position-measuring system).

2. Experiment and results

As an application, a tilting table (angle range 0.02°, angle resolution better than 0.0001°) has been constructed. The setting precisions are limited by the accuracy of the electric current for the Peltier element, and are suitable for a DAFS (diffraction anomalous fine structure) experiment at an epitaxic single-crystal layer [1.9 μm (GaIn)P on [001] GaAs]. To hold the peak position of a Bragg reflection during an energy scan (up to 1 keV in the vicinity of an absorption edge), the coarse positioning of goniometer angles (2θ angle position of the detector, ω incidence angle of synchrotron radiation to the reflecting plane of the

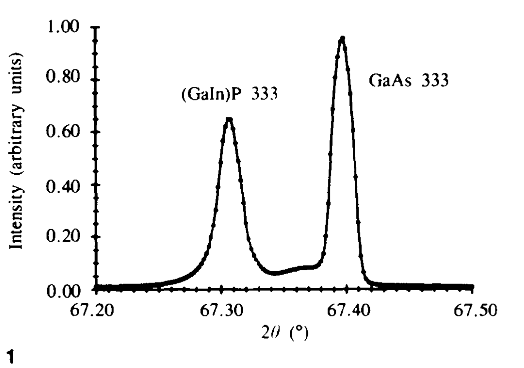

Figure 1
Profiles of adjacent substrate and layer reflections (energy 10 200 eV).

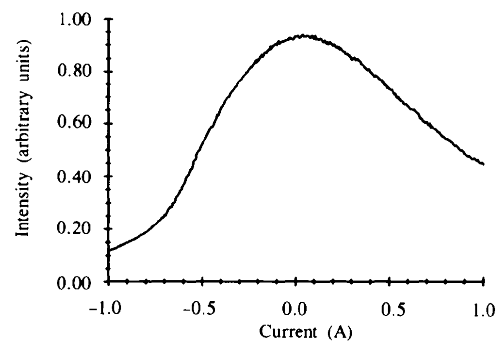

Figure 2
Reflected intensity plotted *versus* the electric current of the Peltier element [energy 10 200 eV, (GaIn)P 333].

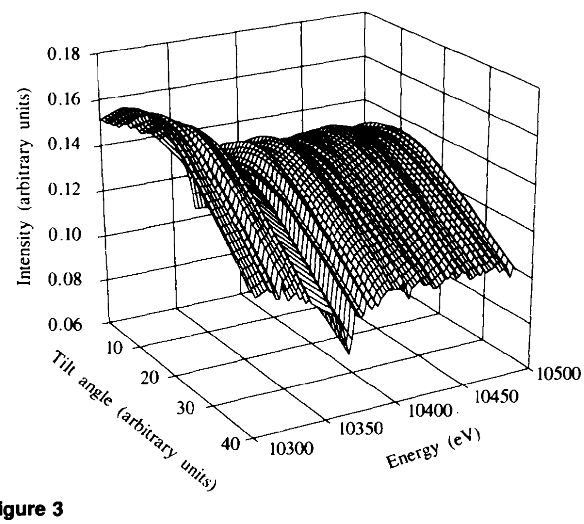

Figure 3
Intensity scans of the (GaIn)P 333 reflection plotted *versus* sample angle ω (scanned with the tilting table) and photon energy.

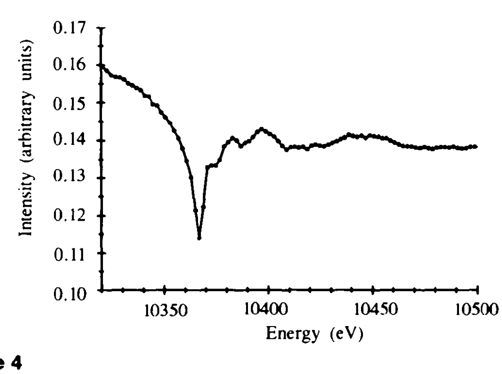

Figure 4
DAFS intensity variation based on the 'raw' data of Fig. 3.

specimen) has to be combined with a fine adjustment of the sample using the tilting-table system. The necessity of doing so is set by the narrow reflection profiles. In Fig. 1 the (GaIn)P 333 and GaAs 333 reflections can be seen. Fig. 2 shows the reflected intensity in the vicinity of the Bragg position of the (GaIn)P 333 reflection as a function of the Peltier element current, driven under computer control.

For a series of energies (step width 2 eV) in the vicinity of the Ga *K*-absorption edge (at 10 369 eV), the goniometer $2\theta/\omega$ was coarsely positioned at the Bragg angle of the (GaIn)P 333 reflection. Additional sample scanning with the tilting table, within an appropriate angle range, results in the intensity field of Fig. 3. Summing up the 11 top intensities of the (fine) ω scans at every energy step yields the DAFS curve section of Fig. 4, demonstrating the results that are possible with this device.

References

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