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Porous InP as Piezoelectric Component in Magnetoelectric Composite Sensors

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We report on the fabrication of cheap piezoelectric porous InP templates by electrochemical etching and additional purely chemical post-etching and on the galvanic filling of the resulting nanopore array with Ni-Fe using a highly viscous electrolyte.
The d_{14} component of porous InP is found to be around a stunning |60| pm/V. The deposited Ni-Fe shows a very narrow hysteresis loop with low coercive field strength (170 G) and very low remanence (0.005 emu).

Introduction

This paper focuses on the production of an effective and cheap piezoelectric material and on the filling with Ni-Fe for the application in a magnetoelectric composite sensor. In this concept porous and piezoelectric InP serves as the matrix material. The pores are then electrochemically filled with a magnetostrictive material. This arrangement of piezoelectric and magnetostrictive materials is chosen, because it allows for very large contact areas, good mechanical coupling between both components, and thus high sensitivity to magnetic fields.

InP, as all III-V semiconductors, is known to show piezoelectric behavior, since InP has no inversion center due to its cubic crystal structure. Thus only the d_{14} component is a non-vanishing component of the piezoelectric modulus (1). The piezoelectric effect of InP has been measured very rarely (2, 3) because even InP with high purity contains too many impurities as doping centers producing a sufficiently large number of free charge carriers that will short-circuit the charges induced by the piezoelectric effect.

Our approach to overcome the short-circuiting of the polarization induced by the piezoelectric effect is to produce a closed packed pore array with overlapping space charge regions, where no free charge carriers are present.

In the second step, these porous InP structures shall be filled electrochemically with strongly magnetostrictive Ni-Fe/Fe-Ga multilayers. Lupu et al. (4) already demonstrated the electrochemical deposition of Ni-Fe and Fe-Ga in commercially available anodic aluminium oxide (AAO) membranes with pore dimensions comparable to the pore dimensions obtained in InP. This paper focuses also on first results concerning the galvanic filling of the pores with Ni-Fe.