Commensurability oscillations in the thermoelectric power of unidirectional lateral superlattices

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The magnetoresistance of a unidirectional lateral superlattice (ULSL) is well known to exhibit commensurability oscillations, which result from the commensurability between the cyclotron radius R_c and the period a of the unidirectional periodic potential modulation imposed on a two-dimensional electron gas (2DEG). Similar commensurability oscillations are theoretically predicted to be present also in the thermoelectric power [1] but, to the knowledge of the present authors, have never been experimentally verified thus far. In the present paper, we report our experimental observation of the commensurability oscillations in the thermoelectric power of ULSLs.

The device for the measurement is prepared from a GaAs/AlGaAs 2DEG wafer. We introduce 1D periodic potential modulation via strain-induced piezoelectric effect by placing an array of electron-beam resist having the period a = 200 nm on the surface of the wafer. As depicted in Fig. 1, the temperature gradient is introduced by heating the center of the Hall bar by an ac current I_h = 70 μA, f = 13 Hz, and the resulting thermovoltage $V_{\alpha\beta}$ ($\alpha,\beta = x,y$) is detected by picking out the component with the frequency $2f$ employing the standard lock-in technique. To investigate the anisotropic behavior, ULSLs with the orientation of the modulation both parallel and perpendicular to the temperature gradient are prepared on the device.

Two components of the thermovoltages, V_{xx} and V_{yx}, are plotted in Fig. 2 along with the magnetoresistivity ρ_{xx} measured in the same sample. Oscillations similar to those in ρ_{xx} are clearly observed in the thermovoltages, but with the phase difference of roughly $\pi/2$. In the thermovoltages, the oscillations are much more prominent in the off-diagonal component V_{yx} than in the longitudinal component V_{xx}, in marked contrast to the case for the resistivity. The oscillations behave basically in accordance with the behavior expected for the thermopowers in ULSLs pointed out in an earlier work by Endo and Iye [2].

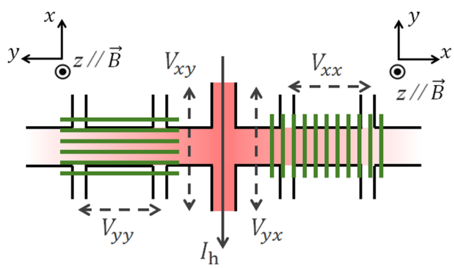

Fig. 1: Schematic diagram of the sample. The temperature gradient is introduced by ac heating current I_h. The direction of the principal axis of the modulation is defined as the x direction for both left and right ULSLs.

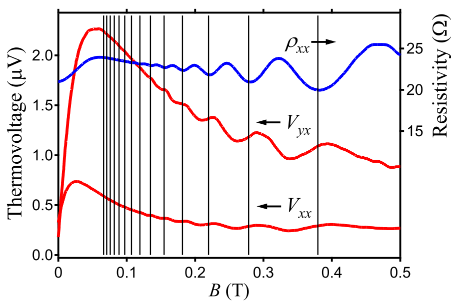

Fig. 2: Thermovoltages and magnetoresistance at T = 3.4 K. Vertical lines indicate the positions of the flat-band conditions, where ρ_{xx} takes minima.

[1] F. M. Peeters and P. Vasilopoulos, Phys. Rev. B **46**, 4667 (1992).
[2] A. Endo and Y. Iye, AIP Conf. Proc. 1339, 617 (2011).