GaAs/AlGaAs Superlattices as Dissipative Room Temperature High-frequency Amplifiers

Vladislovas Čižas [1], Liudvikas Subačius [1], Natalia V. Alexeeva [1], Dalius Seliuta [1], Timo Hyart [2,3], Klaus Köhler [4], Kirill N. Alekseev [1,5], and Gintaras Valušis [1,6]

[1]*Center for Physical Sciences and Technology, Saulėtekio al. 3, Vilnius, Lithuania*
[2]*International Research Centre MagTop, Institute of Physics, Polish Academy of Sciences, Al. Lotników 32/46, 02-668 Warsaw, Poland*
[3]*Department of Applied Physics, Aalto University, 00076 Aalto, Espoo, Finland*
[4]*Fraunhofeer-Institut für Angewandte Festkörperphysik, Tullastrasse 72, Freiburg, Germany*
[5]*Department of Physics, Loughborough University, Loughborough, United Kingdom*
[6]*Institute of Photonics and Nanotechnology, Vilnius University, Saulėtekio Av. 3, Vilnius, Lithuania*

Since the pioneering work of Esaki and Tsu in 1970-ies, quantum superlattices comprising a periodic variation of quantum wells and barriers of different materials are found to be an attracting system for the investigation of a large variety of high-frequency phenomena including Bloch oscillations and frequency multiplication. Also, superlattices can serve as an active environment to generate or amplify radiation reaching THz frequencies [1].

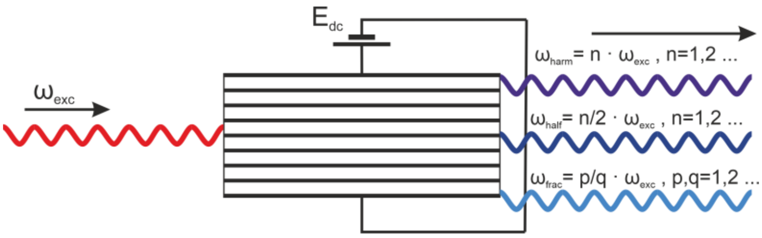

Fig. 1 Spectral response of the biased superlattice in waveguide setup induced by parametric generation effect

However, a majority of works are restricted to theoretical studies, while experimental proof was still lacking [2, 3]. In this presentation, the first experimental evidence of the dissipative parametric gain in the cavityless mode of the superlattice is presented. The experiment was performed in a waveguide-based setup optimised to perform transmission measurements. The subcritically doped superlattice, comprising AlGaAs barriers and GaAs wells, sandwiched between Schottky contact and heterostructure in order to ensure uniform electric field distribution in the structure, was biased by AC and DC fields.

The experiments, performed under the excitation of 8.45 GHz microwave pump in a room temperature environment, indicated a response consisting of harmonics up to the 5^{th} and fractional frequencies. The effect is explained by several multiphoton processes occurring simultaneously. Moreover, the establishment of slow propagating drift-relaxation mode (with the velocity of about 1000 times slower than the speed of light in the material) was revealed, enabling gain reaching levels of 10^4 cm^{-1}. Taking a multiplicity of multiphoton processes into account, obtained experimental results matches the theoretical model [4].

[1] C. Waschke et al., PRL **70,** 3319 (1993).
[2] A. A. Ignatov, K. F. Renk, and E. P. Dodin, PRL **70**, 1996 (1993).
[3] T. Hyart, N. V. Alexeeva, A. Leppänen, and K. N. Alekseev, APL **89**, 132105 (2006).
[4] V. Čižas et al., arxiv:2111.07715, (2021).