Molecular beam epitaxy of GaN nanowires on flexible metal foils: challenges and prospects

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The integration of electronic and optoelectronic devices on flexible substrates is motivated by the promise of novel and/or economically relevant applications. In this context, inorganic semiconductor nanowires have recently emerged as promising candidates for flexible electronics and optoelectronics. Metal foils represent a particularly interesting type of substrate for nanowire growth because they are not only flexible but also exhibit excellent electrical and thermal conductivities as well as a high optical reflectance. In addition, the use of polycrystalline and large area metal foils as substrates might also lead to an increased throughput and a significant cost reduction.

In this work, we discuss the main challenges towards the integration of GaN nanowires (GaN being the material of choice for solid-state lighting and high power electronics) on bare Ti foils as well as on Ni foils covered with a multilayer graphene film. We demonstrate that under optimized growth conditions GaN nanowires on Ti foils have structural and optical properties that are comparable to those of GaN nanowires grown on conventional rigid substrates like Si. We also show that this material system is stable against substrate bending\textsuperscript{1}.

Randomly oriented, uniformly tilted, and vertically aligned GaN nanowires can be grown on Ti foils depending on the crystallinity of the native oxide as well as on the in-situ treatments of the foil surface before nanowire growth (cf. Fig. 1). The growth of vertically oriented GaN nanowires on polycrystalline Ti foils is found to require the presence of an amorphous surface oxide layer, which is effective in interrupting the epitaxial relation between the grains in the foil and the nanowires. An alternative approach for the achievement of nearly vertically oriented GaN nanowires on a flexible and polycrystalline metal foil consists in the introduction of a multilayer graphene film at the substrate surface. Multilayer graphene is found to efficiently interrupt the epitaxial relation between the growing GaN nanowires and the grains in the foils without the introduction of a detrimental insulating amorphous oxide layer. Obtained results represent a first important step towards the fabrication of flexible GaN-nanowire based devices on metal foils.

![Fig. 1: Scanning electron micrographs showing self-assembled GaN nanowires on a Ti foil covered by a crystalline (a)–(b) and an amorphous native oxide (c)–(d) before nanowire growth, respectively.](image)

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\textsuperscript{1} Calabrese, P. Corfdir, G. Gao, C. Pfüller, A. Trampert, O. Brandt, L. Geelhaar and S. Fernández-Garrido, Appl. Phys. Lett. 108 202101 (2016)