# Amorphous $Al_xO_y$ as efficient nucleation layer for selective area formation of GaN nanowires

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We recently reported that self-assembled formation of GaN nanowires (NWs) can be achieved by plasma-assisted molecular beam epitaxy (PAMBE) on crystalline sapphire if the substrate is covered by an amorphous $Al_xO_y$ (a-$Al_xO_y$) layer grown by atomic layer deposition [1]. Moreover, much faster nucleation of GaN NWs was observed on such a-$Al_xO_y$ films than on commonly used nitridated Si substrates ($SiN_x$/Si) under the same growth conditions [2, 3]. Despite these promising advantages, high density of NWs and controlling of their spatial distribution on a substrate still remain an issue.

In this work GaN growth was performed by PAMBE on GaN/sapphire and $SiN_x$/Si substrates with 12 μm wide stripes of 15 nm thick a-$Al_xO_y$. Formation of GaN NWs well-aligned perpendicularly to the substrate surface was found on a-$Al_xO_y$ stripes, while a rough compact GaN layer was obtained on bare, crystalline parts of GaN/sapphire template. Since the compact layer forms under N-rich conditions while the growth of GaN NWs takes place under local excess of Ga [4, 5], the ratio of NW length $h$ to the thickness of the compact layer $d$ can be tailored by adjusting the $\Phi_N/\Phi_{Ga}$ flux ratio and the growth temperature. The respective modelling was performed taking into account the NW incubation time as a function of growth parameters [6]. In agreement with calculations we found that the value of $h/d$ ratio can be increased by increasing the $\Phi_N/\Phi_{Ga}$ flux ratio. On the other hand pure selective area growth (SAG) was observed on $SiN_x$/Si substrates with a-$Al_xO_y$ stripes. This was achieved by adjusting the growth parameters that nucleation of GaN on $SiN_x$ was prevented (incubation time longer than the growth duration), so GaN NW growth took place on a-$Al_xO_y$ stripes only. Importantly, the same effect of pure SAG was found for PECVD-deposited $SiN_x$ on GaN/sapphire templates. In that way, our results pave the way for SAG of GaN NWs on a wide variety of dissimilar materials by using a-$Al_xO_y$ as the nucleation layer.

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