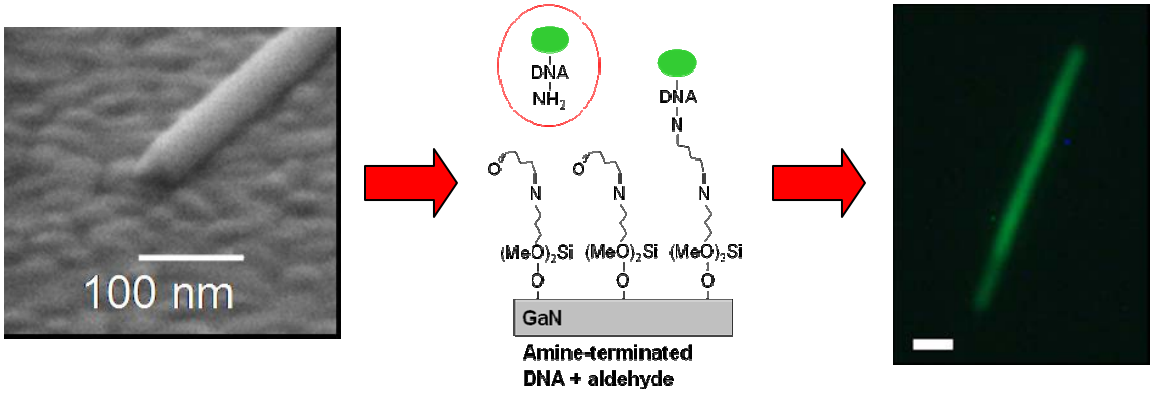
Surface Modification of Semiconductor Nanowires and Their Properties

Nanowires (NWs), which can now be made from metals, semiconductors and insulators, have advantages over bulk materials for many electronic, optical and energy applications ranging from chem/bio-sensors to nanoscale lasers. The enormous surface-to-volume ratio of NWs dramatically enhances the impact of surface condition on the NW's electrical or optical performance. Thus, understanding and control of surface phenomena are required to develop technologically relevant nanowire-based devices.

For example, the interaction of a GaN NW with ambient oxygen or water can alter the NW's electrical conductivity by orders of magnitude due to surface depletion effects. Surface traps may lead to persistent photo-conductivity in NWs, which affect their AC and DC device response and other fundamental properties. We have characterized these traps, their effects on device response, and potential passivation schemes.

Understanding of the surface also permits proactive control of nanostructure functionality. Designing appropriate surface treatments enables a NW to selectively bind target species that alter the NW conductivity or optical emission. This approach has been applied to development of chem/bio sensing technologies. We have applied silane- and phosphonic acid-based chemical functionalizations to NWs. The GaN NW (pictured left) was exposed to a silane-based chemistry (center). This chemical treatment results in a robust and versatile layer to which we have attached fluorescently tagged single stranded DNA (right) as well as two separate ligand-receptor systems. The reaction of such a DNA-treated wire with a complementary DNA strand can be monitored by a simple change in electrical conductivity. Interaction between surface species and wave-guided optical modes offer the potential for more complete interrogation of these molecules.



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