Research and development of efficient high-power electronics is a very important path for the environment-friendly progress. Also, the low cost of electrical power is a key driver of world-scale development and socio-economic vitality. Especially research and development of gallium nitride (GaN) based electronics is expected to drastically cut energy consumption for both consumer applications and power transmission utilities.

The material limits of GaN far exceed those of typical semiconductors used for high power devices, such as silicon (Si), indium phosphide (InP) or gallium arsenide (GaAs). GaN-based power electronics would be the inevitable successor to silicon in the advancement of power management because of its incomparable efficiency and speed (switching frequency).

GaN epitaxial layers are usually grown on expensive SiC substrates, which beside relatively low lattice mismatch offer very good thermal conductivity. The cost can be lowered if e.g. sapphire crystals are used, but the drawback is the higher lattice mismatch and poor thermal conductivity.

In recent years Si substrates for GaN-on-Si electronics have gained attention. Although the lattice mismatch is high, the thermal conductivity of Si is better than in the case of sapphire substrates. The modern solutions for epitaxial growth open a gateway for a further, huge benefit that can be achieved if GaN based devices can be manufactured using silicon technology. High-area Si substrates which can be then applied and availability of advanced silicon foundries can bring GaN-based transistors and circuits to a substantially larger market.

In order to be compatible with Si technology, GaN-based devices have to meet special requirements. It is very important to eliminate gold from manufacturing process, as it is not acceptable in silicon devices technology, because Au acts as a deep level contamination (called “lifetime killer”) with high diffusivity in Si. In contrast, in typical GaN-based devices like High Electron Mobility Transistors (HEMTs) the gold is commonly used as top-level metal for inter-connection purposes.

A solution could be an application of copper instead of gold. Cu has a lower resistivity, higher thermal conductivity and much lower cost. However, Cu can easily diffuse into GaN causing deterioration in device characteristics. In these terms, high-barrier Schottky contact utilized as a gate electrode in GaN HEMTs requires particular attention. Namely, there is a need for a Shottky contact with high barrier and low leakage currents that at the same time will block diffusion of Cu toward the substrate and preserve its properties at high temperatures.

As a potential solution, we propose to explore metal silicides as Schottky contacts to GaN epitaxial structures and simultaneously as diffusion blocking layers. Although promising clues can be drawn from recent scientific reports, the current state of knowledge in this field is limited and extensive fundamental experiments are needed.

Specifically, there is a need for understanding how the Schottky barrier forms in such contacts and how it is affected by the exposure to high temperatures. As power devices due to self-heating inevitably operate at high temperatures it is also necessary to determine temperature-related phenomena that can affect performance of the devices like diffusion-related introduction of charge carrier traps into the semiconductor.

The experiments that are planned in the Project will provide extensive knowledge about phenomena induced by high temperatures in GaN epitaxial structures with silicide-based Schottky contacts. Deep understanding of mechanisms affecting the properties of semiconductor and contact will be necessary in future e.g. for designing HEMT transistors compatible with Si technology. It can have potentially great impact on lowering costs of efficient high power devices and therefore make a remarkable step toward more environment-friendly society.