

Abstract

The greatest weakness of current circuits is thermal. Localized temperature increase can significantly degrade a circuit performance, sometimes irreversibly. In this thesis, we investigate the potential of replacing copper interconnects in 3D architecture with an alternative hybrid carbon structure: carbon nanotubes covalently bonded to graphene/graphite horizontal interconnects. The structure is highly conductive both thermally and electrically and can sustain higher current densities than currently used copper interconnects. We also focused our interest in studying the thermal degradation mechanisms of such carbon-based devices. To do so, we first studied the joule-heating induced electrical failure of graphene based devices (electro-burning). From our observations, the presence of defects greatly influences the electro-burning of graphene. To gain more insight into this degradation, we used a femtosecond laser to locally induce thermal damage to the graphene. Finally, we showed how electro-burning, when controlled, can be an advantage. We use a tightly focused femtosecond laser beam to induce defects in graphene according to selected patterns. We show that, contrary to the pristine graphene devices where nanogap position and shape is uncontrolled, the nanogaps in pre-patterned devices propagate along the defect line created by the femtosecond laser. Using passive voltage contrast combined with atomic force microscopy, we confirmed the reproducibility of the process with a 92% success rate over 26 devices.

Keywords: Thermal management, graphene, carbon nanotubes, electro-burning, laser irradiation