Abstract for general public

Everyone has experienced the heating of electronic devices, which is due to increasing power and packaging density. This heat needs to be removed to assure the proper functionality of the components. According to statistical data, more than half of the electronic components failure cases are due to the overheating. The thermal management has become a very critical issues because of a lack of materials which could sufficiently effective spread or sink heat generated by electronic devices.

In this project, we would like to elaborate an in-depth understanding of the behavior of submicro- and nano-structured Cu-Mo composites. Based on this understanding, we will derive the design rules for the composites with properties required for effective thermal management, such as high thermal and electrical conductivity, adjusted coefficient of thermal expansion and good mechanical strength, ductility and corrosion resistance. The rules will be experimentally validated through the preparation of Cu-Mo composites with desired properties by controlling their architecture, microstructure, texture and interface properties.

Cu-Mo composites were selected because they exhibit an unique combination of high thermal and electrical conductivity and low thermal coefficient, which makes them promising heat spreaders and heat sinks materials for the future, especially in hybrid electric vehicles, cellular base stations or space applications. In addition, their thermal conductivity as well as coefficient of thermal expansion can be adjusted to the requirements ("materials on demand") by controlling the ratio of Cu-Mo and the composite architecture. Furthermore, our recent research results indicate that the performance of the heat spreader materials such as Cu-W or Cu-Mo can be improved through their nano-structuring and engineering of interface properties. However, the optimal material performance under specific conditions strongly depends on the precise materials design down to the nanoscale.

Within the project, we will study the behavior of Cu-Mo composites with engineered microstructures and textures ranging from nanostructured to fine-grained. For this, Cu-Mo (multi)nanolayers with a single layer thickness between 3-10 nm will be deposited by magnetron sputtering and fine-grained Cu-Mo sandwiches will be manufactured by severe plastic deformation of commercial Cu-Mo-Cu sandwiches. The functional (thermal/electrical conductivity, thermal coefficient of expansion) and mechanical properties (mechanical strength, hardness and ductility) of these materials as well as their solderability or brazeability will be studied and compared with the properties of the commercial Cu-Mo composites (Cu-Mo-Cu-Mo-Cu sandwiches and infiltrated Cu-Mo composites). The main focus will be directed on the effect of characteristic microstructure features, i.e. size (nano, submicron) and the multi-scale interfaces (grain boundaries, hetero-phase and surface complexions) on the composite properties. Special attention will be drawn to the less-understood nanoscale effects in this material system, such as the effect of the confinement on the thermal conductivity and strength in Cu-Mo composites.