

High frequency substrate technologies for the realisation of software programmable metasurfaces on PCB hardware platforms with integrated controller nodes

Dionysios Manassis¹, Manuel Seckel¹, Liu Fu², Odysseas Tsilipakos³, Alexandros Pitilakis³, Anna Tasolamprou³, Kypros Kossifos⁴, Christos Liaskos³, Maria Kafesaki³, Sergei Tretyakov², Julius Georgiou⁴, Andreas Ostmann¹, Rolf Aschenbrenner¹, Martin Schneider-Ramelow¹, and K-D. Lang⁵

¹Fraunhofer Institute for Reliability and Microintegration (IZM), Gustav-Meyer-Alle 25, 13355 Berlin, Germany

²Aalto University, Dept. of Electronics & Nanoengineering, FI-00076 Aalto, Finland

³ Foundation for Research & Technology – Hellas /FORTH, 71110 Heraklion, Crete

⁴University of Cyprus, Dept. of Electrical & Computer Engineering, 1678 Nicosia, Cyprus

⁵Technical University of Berlin, Gustav-Meyer-Alle 25, 13355 Berlin, Germany

ABSTRACT

The proposed work is performed in the framework of the FET-EU project “VISORSURF”, which has undertaken research activities on the emerging concepts of metamaterials that can be software programmable and adapt their properties. In the realm of electromagnetism (EM), the field of metasurfaces (MSF) has reached significant breakthroughs in correlating the micro- or nano-structure of artificial planar materials to their end properties. MSFs exhibit physical properties not found in nature, such as negative or smaller-than-unity refraction index, allowing for EM cloaking of objects, reflection cancellation from a given surface and EM energy concentration in as-tight-as-possible spaces.

The VISORSURF main objective is the development of a hardware platform, the Hypersurface, whose electromagnetic behavior can be defined programmatically. The key enablers for this are the metasurfaces whose electromagnetic properties depend on their internal structure. The Hypersurface hardware platform will be a 4-layer build-up of high frequency PCB substrate materials and will merge the metasurfaces with custom electronic controller nodes at the bottom of the PCB hardware platform. These electronic controllers build a nanonetwork which receives external programmatic commands and alters the metasurface structure, yielding a desired electromagnetic behavior for the Hypersurface platform.

This paper will elaborate on how large scale PCB technologies are deployed for the economical manufacturing of the 4-layer Hypersurface PCB hardware platform with a size of 9”x12” and 12”x12”, having copper metasurface patches on the top of the board and the electronic controllers as 2mmx2mm WLCSP chips at 400µm pitch assembled at the bottom of the platform. The PCB platform designs have stemmed from EM modeling iterations of the

whole stack of high frequency laminates taking into account also the electronic features of the controller nodes. The manufacturing processes for the realization of the selected PCB architectures will be discussed in detail.

Keywords: substrate materials, PCB technologies, metamaterials, software driven metasurfaces.