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Conformal Electromagnetic Skin Based on Flexible Materials

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In the last years the diffusion of wireless sensors for health related applications is increasing exponentially. The unlicensed millimeter-wave (mmW) band around 60 GHz offers advantages in terms of miniaturization and wide bandwidth. Since these devices operate in contact or in proximity of the human body, they need to be tested in real exposure condition. While for ethical reasons compliance testing is not performed directly on human beings, it is possible to use phantoms that reproduce the electromagnetic (EM) properties of biological tissues. Compared to liquid [1] and semisolid phantoms [2], solid phantoms have the advantage to be long lasting and do not require any shell [3]. However, at mmW it is challenging to find a combination of materials that allow to match the permittivity of the skin ($\varepsilon_r = 7.98 - j10.90$) without using water. The only available solution are solid, but rigid phantoms, that are representative only for a predefined posture of the body. As an alternative solution, this paper proposes a skin-equivalent solid and flexible phantom that reproduces the reflection coefficient at the air/skin interface in the 55–65 GHz range. The phantom consists in a 2.1-mm layer of silicone and carbon powder (40% of the composite weight) backed by an electrotextile (Fig.1a). The thickness of the silicone/carbon layer is optimized to approach the skin reflection coefficient when considering a transverse magnetic (TM) or transverse electric (TE) impinging plane wave for the angles of incidence from 0° to 60°. The maximum relative error between the reflection coefficient of the realized phantom and the skin is 2.6% for the magnitude and 13%. The phantom has been experimentally validated using a free-space transmission/reflection system. The measurement results of the magnitude of the reflection coefficient for normal incidence (see Figure 1b) are in good agreement with numerical simulations, showing a relative error within 1.9% in the 55–65 GHz range. Such a phantom represents a promising solution for body-centric measurements where reconfigurable, flexible, conformal or dynamic body models are necessary.

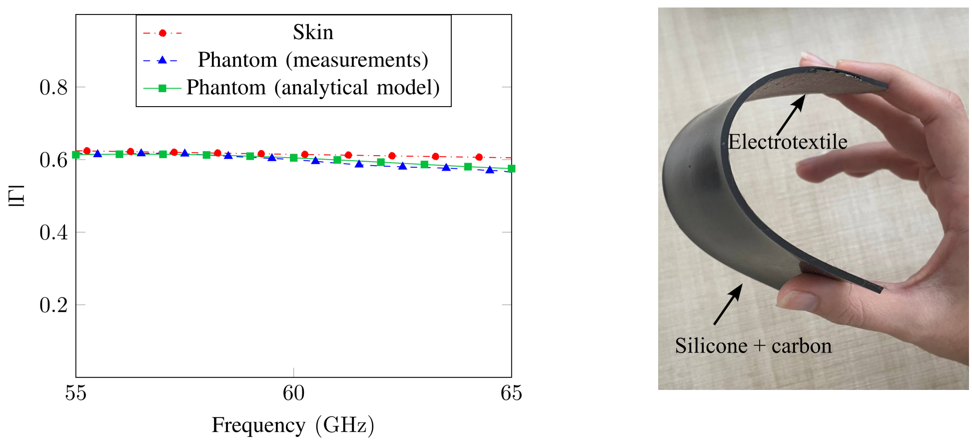

Figure 1. (a) Realized phantom and (b) measured reflection coefficient magnitude for normal incidence.

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