Body Motion detection using epidermal electronic graphene patches

L Schaberg[1], T Kubiczek[1], S Santhakumaran[1], R Burkard[1], W Mertin[1], F Muckel[1], G Bacher[1], AL Schall-Giesecke[2], D Neumaier[3], JC Balzer[1], EA Kirchner[1], N Benson[1]

[1]University of Duisburg-Essen, Duisburg

[2]Fraunhofer - IMS, Duisburg

[3]University of Wuppertal, Wuppertal

Introduction

Rehabilitation aiming at patient mobilization often requires mechanical guidance, using equipment such as motorized exoskeletons or prosthetics. The state of the art enables this using complicated setups, where sensors are a vital part of the human machine interface. Yet, as typically one sensor is attached to one cable, depending on the complexity of the system, this has strong limitations in terms of errors, interference and patient comfort. Epidermal electronics is a potential solution, conforming directly to the surface of the skin and capable of integrating a multitude of sensors without negatively impacting patient comfort. Yet, despite all its promise, real world applications have eluded epidermal electronics so far, due to Young's modulus, silicon front end and substrate breathability challenges.

Methods

Here, we introduce a concept, which completely rethinks epidermal electronics to address above issues, and to enable passive, wireless exoskeleton or prosthetics control. Our approach makes use of the unique THz properties of Graphene, which are tuneable by electronic gating, such as by muscle induced skin surface potential variation, enabling the efficient control of THz reflection and absorption. This makes passive and wireless epidermal electronics possible, relying only on an external THz transceiver, e.g. exoskeleton or prosthetic integrated, which measures muscle movement in reflection from a graphene based passive and chipless epidermal electronic matrix.

Results

A proof of principle of this concept will be demonstrated, using a Reconfigurable Intelligent Surface (RIS) based on Al / AlOx / Graphene / Au stack, where the Au electrode features graphene windows, allowing THz reflection measurements in dependence of the potential difference between the two electrodes. This is evaluated in the 500GHz to 3THz range, using a TDS system with a spectral range >6 THz and a single shot dynamic range of up to 60dB.

Conclusion

By controlling the skin surface potential dependent THz absorption and reflection of Graphene, a novel chipless and passive epidermal electronics concept becomes feasible, for which as a proof of principle is demonstrated here using a gateable RIS.