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Integrated metrology devices dedicated to transient Harman measurement of silicon nano-meshes

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In thermoelectricity, silicon nanostructures represent an interesting alternative to conventional thermoelectric materials due to Si abundance, non-toxic nature and its compatibility with CMOS technology. Researchers have investigated methods to enhance the silicon figure of merit zT by increasing the σ/κ ratio; decreasing the thermal conductivity κ by (i) using nanometric structure such as thin membranes [1,2,3] or nanowires [4,5], (ii) roughening [5,6], (iii) oxidization of the surface [7] achieved relatively low value of κ . Yet, few experimental measurements of zT in crystalline silicon nano-objects were presented with important data dispersion (Figure 1). Usually, the thermoelectric figure of merit is obtained through independent measurement of materials transport properties (κ , σ and S). The uncertainty of zT can easily reach 50% considering that each parameter has an uncertainty of 5% to 20% [8]. Harman's technique [9] is a simple and rapid method to measure zT directly in bulk materials. In this work, we propose an adaptation of the transient Harman technique to suspended crystalline nanomembranes. Additionally, following [10], a correction factor taking into account radiation, contact resistances and Joule effect is determined. Finally, we present a device implementation of the method that enable direct access to zT through purely electrical measurements without relying on separate measurements of transport parameters.

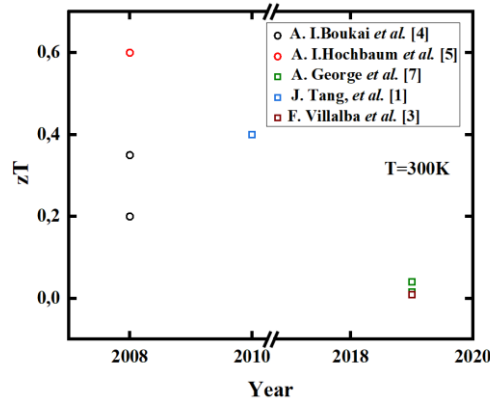


Figure 1: Reported values of zT for crystalline silicon planar configurations.

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