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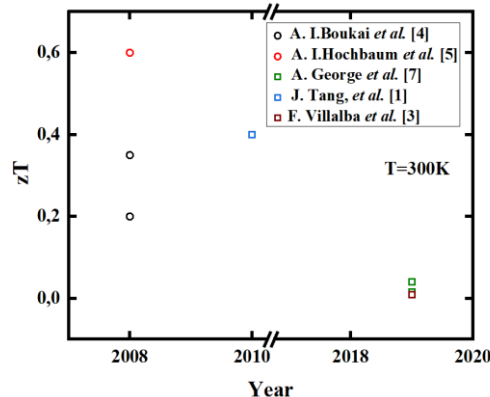
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# Integrated metrology devices dedicated to transient Harman measurement of silicon nano-meshes

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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  $\sigma/\kappa$  ratio; decreasing the thermal conductivity  $\kappa$  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  $\kappa$ . 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 ( $\kappa$ ,  $\sigma$  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.

- [1] J. Tang *et al.*, Nano Lett. **10**, pp. 4279–4283 (2010).
- [2] M. Haras *et al.*, IEEE Electron Device Letters, **37**, 1358 (2016).
- [3] P. Ferrando-Villalba *et al.*, Nanomaterials, **9**, 653 (2019).
- [4] A. I. Boukai, *et al.*, Nature, **451**, 168–171 (2008).
- [5] A. I. Hochbaum *et al.*, Nature, **451**, 163–167 (2008).
- [6] X. Huang *et al.*, ACS Appl. Mater. Interfaces, **11**, 34394–34398 (2019).
- [7] A. George *et al.*, ACS Appl. Mater. Interfaces, **11**, 12027 (2019).
- [8] G. J. Snyder and E. S. Toberer, Nat. Mater., **7**, 7105–114, (2008).
- [9] T. C. Harman, J. Appl. Phys., **29**, 1373–1374 (1958).
- [10] B. Kwon *et al.*, Rev. Sci. Instrum. **85**, 045108 (2014).