B09-3

Flexible thin-film planar Peltier microcooler

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The present work reports the fabrication and characterization of the first planar Peltier microcooler on flexible substrate. The microcooler was fabricated on flexible Kapton© polyimide substrate, 25 μm thickness, using Bi_2Te_3 and Sb_2Te_3 thermoelectric elements, deposited by thermal co-evaporation method.
The cold area of the device (4 mm2) is cooled using four pair of thermoelectric elements, connected in series with aluminum / nickel contacts. Flexible substrates add uncommon mechanical properties to the composite film-substrate and enable their integration with many novel types of electronic devices. Kapton was chosen as substrate because of its low thermal conductivity ($0.16\ W.m^{-1}.K^{-1}$), enabling higher performance on cooler devices. The value of thermal expansion coefficient of Kapton ($12\times10^{-6}\ K^{-1}$), which closely matches the thermal expansion coefficient of the telluride films, reduces residual stress and increases adhesion of thermoelectric films. Thermoelectric films were deposited by co-evaporation of Bismuth and Tellurium or Antimony and Tellurium respectively for the Bi_2Te_3 or Sb_2Te_3 films. Optimal growing deposition parameters allow the fabrication of films with power factor of $4.8\ W.K^{-2}.m^{-1}$ and $2.8\ W.K^{-2}.m^{-1}$ respectively for Bi_2Te_3 and Sb_2Te_3, values that are comparable with the best published results for the same material, under various fabrication methods (thermal co-evaporation, sputtering, MOCVD, flash-evaporation, or ECD).
The performance of Peltier microcooler was analyzed by infrared image microscope, on still-air and under vacuum conditions, and the temperature difference between the cold side and the hot side of the device was measured and compared with literature available for Peltier microcoolers on rigid substrates.

B09-4

A new approach, platform-based and modular, for conceiving, developing and manufacturing thermoelectric assemblies for a wide range of niche applications, each one with low-to-medium volume potential

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Thermoelectric technology has a transversal and multipurpose character with respect to applications and it can lead to original solutions for a wide range of thermal issues and user's common thermal needs. The spread of thermoelectricity on many niche applications is hindered and slowed down by the difficulty to develop and industrialize thermoelectric assemblies which need a well balanced integration of thermoelectric modules, heat exchangers and heat sinks, and must be optimized in performance while also reaching a high quality level at a reasonable cost, even for the low-to-medium volume potential of each niche application.
The work will summarize the achievements of an original platform approach applied to the engineering of thermoelectric assemblies: a modular architecture made of a set of base components with common interface definitions, using the same thermo-mechanical coupling methods, ruled by the constraints of geometry construction guidelines and common assembly methods. Originally designed modular components are part of the platform's base set of parts as well as identified commercial components, that are all individually characterized with respect to the constraints of platform's architecture.
A proprietary mathematical model to predict performance of any assembly built out of the platform has been developed and is maintained together with a database of platform components' characteristics, properties and cost, thus permitting to conceive new solutions upon any special application's requirements, with accurate and reliable prediction of performance and manufacturing costs. Moreover, prototyping a new custom solution corresponds to just sampling a new combination of well known elements within the well known platform architecture, setting the premises for the shortest time-to-market for any new solution.