Development of Miniaturized Peltier Element Towards Temperature Control Within Microfluidic Systems

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Peltier elements, founded on the principle of thermoelectricity, have proven themselves to be indispensable tools in achieving and maintaining precise temperature control at the microscale, particularly in microcalorimeters and microfluidics. This presentation describes the fundamental operation, construction, and potential applications of Peltier elements within the context of microfluidics, elaborating on the critical role they can play in addressing the thermal challenges that often beset low thermal conductivity, polymeric microfluidic systems. We report the development of an 8 mm x 5 mm x 5 mm, 3D printed, polyethylene glycol diacrylate (PEGDA)-based microfluidic Peltier element, with thermoelectric legs made with organic p type and n type polymers (PEDOS.PSS and BBL: PEI, respectively). Conventional Peltier elements are designed as an array of a series of rigid, thermoelectric legs, which is a difficult configuration to build within microfluidic devices and are limited to a small number of thermoelectric legs due to size constraints. The unique configuration of this new Peltier element uses a three-part microfluidic chip-to-chip design, an innovative method for injecting the devices with p and n type polymers and the ability to potentially reach 224 thermoelectric legs for the size mentioned. The performance of this new Peltier element device is compared to millimeter sized, commercially available Peltier elements. The development of a smaller Peltier element will enhance the efficiency of thermodynamic investigations of biomolecules, enabling more rapid response times and requiring smaller sample sizes.