Continuous Micro Roll Forming to Enable Energy Efficiency Devices

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**Objective:** The objective of this ISEN award is to conduct a preliminary work in the design and cost-analysis of a micro-rolling process, aiming to establish an economically sustainable manufacturing method that creates patterns or textures on thin sheets made of hard materials. The applications of patterned sheets include the lamina consisting of thousands of microchannels that facilitate heat exchange or mass transfer for distributed power generation, fuel cell power systems, hydrogen generation, and nanomaterial deposition for solar cell fabrication; and micro-textured surfaces for friction reduction and alternation of cell attachment.

**Approach:** Microchannels in metallic lamina are currently manufactured through photochemical machining, which is a relatively slow process and poses material waste and environmental concerns. We propose to investigate the process capability of a continuous micro roll forming of thin sheets in the order of a few hundred microns, as an alternative fabrication method to photochemical machining.

**Results:** A prototype of the micro-rolling process was designed and fabricated as shown in Fig. 1. It has a set of rollers with features to deform a flat sheet metal into a shim stock with microchannels. The proposed process is a net-shape manufacturing process based on the deformation theory, which has a minimum material waste. Using the combination of piezo actuator and flexure hinge design, the microforming apparatus is designed to have the precision in sub-micrometers. In addition, a cost model was developed to compare this new process with the existing photochemical machining process. The result is shown in Fig. 1c. It can be seen that microforming has a profound advantage in high volume production.

![Fig. 1](image-url)