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# Visualization of the Flow Pattern in the Rectangular Microchannel of a Miniature Heat Exchanger

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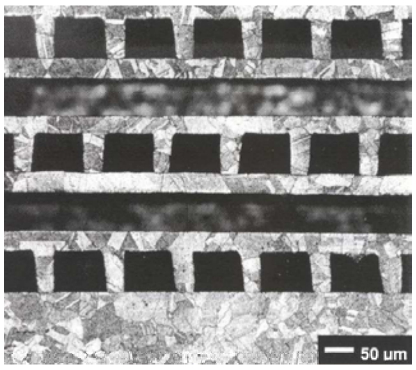


Fig. 1. Polished cross section of a diffusion-welded pile of elements forming a cross-flow heat exchanger element. Here: stainless steel.

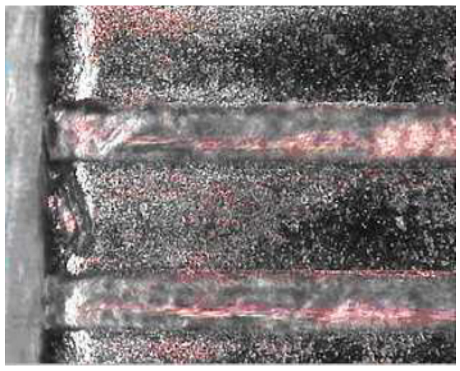

Fig. 2. Photo (top view) of a channel and the web walls (inlet on the left).

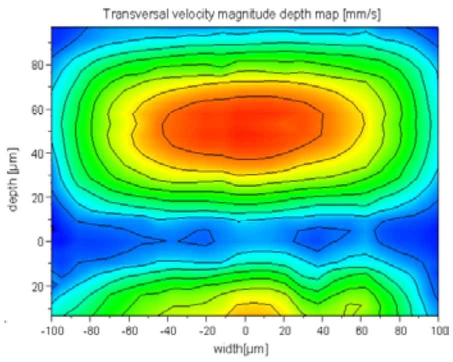


Fig. 3. Velocity map in a transversal plane of the plane of the channel (fully developed flow).

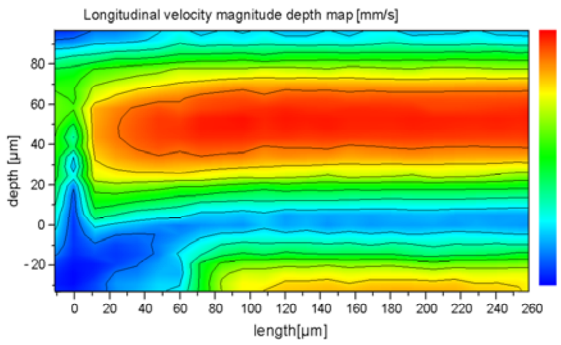


Fig. 4. Velocity map in the longitudinal middle channel (flow direction: left to right).

The cross-flow micro-channel heat exchangers are composed of slices, into which the channels are engraved by grinding ribbons. The rectangular channels have typical widths of 100 to 200 µm and a height of about the same dimensions. Web walls about 100 µm broad separate the channels. The slices are piled up and diffusion-welded to a heat exchanger segment (Fig. 1). Neighboring slices have orthogonally directed channels, therewith, creating the cross-flow heat exchanger.

The measurements reported here stem from the third generation of heat exchanger elements (copper made), presented in Fig. 2, which shows a photo (top view) of a channel and the web walls (inlet on the left); one may note the inlet dip and the near perfect mirror-like smoothness of the copper bottom at some distance from the cut inlet edge. The transition region from rough to smooth differs from one channel to the next.

The flow pattern in Fig. 3 gives the velocity field in a fully developed flow cross section. The flow was mapped throughout the channel depth experimentally, by acquiring PIV (particle image velocimetry) data in parallel planes approx. 5 µm apart. By re-plotting the data, it was transformed into depth velocity maps. The appearance of a mirrored velocity map, below the zero level, is induced by the near perfect mirror-like smoothness of the copper channel bottom (Fig. 2). As the images of the particles are mirrored, the measured velocity maps will show the effect alike, if measurement will be continued below the “zero” level.

Figure 4, which maps the velocity in the longitudinal middle plane of the channel, shows, from left to right: the inlet flow from the flat cell, the mechanical “dip” before the inlet, the onset of channel flow stabilization, the appearance of a mirror profile, below the zero level.