From the figures it appears that the amplitude of the rate of shear or defined helicity is lower as Reynolds number is increased. The mean or average shear or helicity over the cycle appears to be independent of Reynolds number. The authors state that chaotic advection was not present for this geometry. The authors state that patterned grooves in microchannels create dead volumes but that deeper features also improve mixing and reduce the channel length for mixing. These mixers are stated to work at a relatively low flow velocity (Re<5) which reduces pressure drop.

Bennett and Wiggins published, in 2003 on the web a comparison of various geometries of the SHM. Specifically, the short legs were removed and the grooves were halved and doubled in depth. The Reynolds number was less than 0.1. Improved mixing was found with the double depth grooves over the original SHM, where removing the short legs was slightly worse as was the half depth grooves over the original SHM. The authors state the effectiveness of the mixer as a result of ditch mixing, where some fluid is shuttled across the channel in the groove or ditch to add more shear to the fluid and thus enhance mixing. As a result of this proposed mechanism, the authors suggest that the short legs of the SHM may be removed with very little impact—thus creating features with only one angle. The authors also state that the pressure drop for the grooved channels is less than the simple grooveless channels because the openings of the grooves effectively act to weaken the no-slip boundary condition. Finally, the authors discuss the mixing length as an increasing function with the log of the Pe. That is the mixing length increases with either an increasing velocity or diffusion distance or a decreasing mass diffusivity.

Kim et al in April 2004 published the use of a barrier embedded chaotic micromixer, where a barrier is placed within the main flow channel in addition to a series array of angled grooves that contain one angle per feature. The authors note that features could be patterned on both the top and bottom of a channel and that stronger helical flows could be achieved. The authors suggest that stronger helical flows will create higher order mixing. The groove depth to channel gap ratio is 0.15. The height of the barrier is 40 microns extending into the 60 micron microchannel gap. The Reynolds number varied from 0.228 to 2.28. The authors show that the mixing intensity decreases as the Reynolds number increases within a given length of microchannel (21 mm), and that the mixing length increases logarithmically with increasing Reynolds number.

Also in April 2004, Schonfeld and Hardt published work on helical flows in microchannels. They state that heat transfer from the channel walls is enhanced and hydrodynamic dispersion of concentration tracers transported through a channel is reduced. They numerically evaluated a surface feature pattern with one oblique angle groove on either one or two walls of the microchannel with a ratio of groove depth to channel gap from 0.02 to 6.3. The authors state that the average of the ratio of transverse velocity vectors in the y (channel width) and x (channel length) planes within the surface features increases linearly from −1 to −0.4 in the groove well and then increases exponentially in the main channel flow path until leveling off at the channel center line at zero or essentially no net cross channel flow in the bulk flow channel. The cross channel flow vectors move back and forth at roughly the same velocity. The authors state that with two walls, the lamellae entanglement of the two fluid streams to be mixed is increased thus creating an enlarged interfacial surface area for diffusive mixing in the main channel. The authors analyzed the dependency of the relative transverse velocity on Reynolds number and reported finding a surprisingly weak dependency. The absolute transverse velocity within the oblique ridges is enhanced when the Reynolds number varies from 1 to 1000, the relative transverse velocity above the structures is only scarcely affected. For the cases stated, the ratio of average y and x velocity in the main channel is about zero across the gap of the microchannel. As Reynolds number increased, the relative velocity of fluid across the main channel in the width direction was not changed.

Locascio published in May 2004 a summary of microfluid mixing. She stated that mixing was induced by fluid rolling or folding as it passed over the features at the bottom of the channel. Little fluid motion is shown at the bottom of the channel. Mixing in the groove channel devices occurred by diffusive mixing that was enhanced by reducing the diffusion length between two fluids through the folding effect.

Also in May 2004, Kang and Kwon published a comparison of the slanted groove micromixer (all features with one angle), the SHM, and the barrier embedded micromixer. Each had a ratio of groove depth to channel gap of 0.1765. Each contained 24 features in series, where the SHM had two sets of 12 features where the apex of the two-angled feature moved from one side to the other side of the channel. The Reynolds number is stated to be on the order of 0.01. The slanted groove mixer is stated to be a poor mixer and the SHM to be the best mixer. The in channel flow patterns show a folding and blending of material in the main flow channel.

Liu, Kim, and Sung published in July 2004 a study evaluating grooved micromixers. The dimensions from Strook's Science article were scaled with a constant aspect ratio to evaluate a channel with a hydraulic diameter of 200 microns versus 111 microns. The resulting ratio of groove depth to channel gap was 0.23. The mixing performance at a Reynolds number of 1 was slightly better than at a Reynolds number of 10. The authors state that the mixing performance deteriorated at higher Reynolds numbers due to a significant reduction in the residence time of the fluids inside the mixer.

Strook and McGraw in March 2004 published a simple lid-driven cavity flow model to qualitatively compare the mixing patterns to actual experiments. The model looked at the SHM with a total surface feature repeating unit length of 0.9 mm. The groove depth to channel gap is 0.44. The Stokes flow of Reynolds number approaching 0 was used in the model to compare with the Re=0.01 flow. Qualitatively the model described the results of the experiment, specifically that the movement of one "lobe of fluid" from one lobe right to left and one from left to right through the SHM grooves. However, the models Stokes flow relegates it to non-inertial flows where flow inertia can't compete with momentum diffusion.

Sato et al published in November 2004 a study with slanted single angle feature on 3 walls. The authors describe a tight spiral flow that is created. The ratio of groove depth to channel gap is 0.3. The authors state better results when the features on the two side walls are shifted, where 5 slant grooves in a row are present on one side wall then stop while 5 slant grooves in a row start on the opposing side wall and stop and so on. The Reynolds number is less than 10 for this work.

Howell et al in April 2005 published a study with grooves placed on the top and bottom of the microchannel. The grooves consisted of a set of 4 slanted single angle grooves followed by four chevron grooves then followed again by 4 single angle grooves and so on. The ratio of groove depth to channel gap ranged from 0.24 to 0.74. the Reynolds number studied ranged from 0.06 to 10. The flow primarily stretched and folded in the main flow path to create more closely spaced