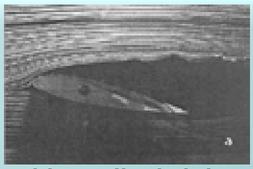
Presented at the COMSOL Conference 2009 Milan

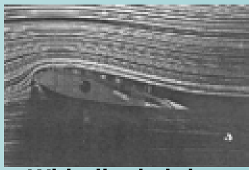
Tilted Micro Air Jet for Flow Control

Introduction & Purpose

In aeronautic field, one tries to control airflow close to aircraft wing. A new method consists in producing micro air jets coming from wing surface to avoid turbulences and in order to improve aircraft aerodynamic performances. These micro air jets have several characteristics such as speed, frequency and tilt. We fabricated on a silicon substrate a passive fluidic microsystem able to produce a tilted micro air jet. The specific air jet angle depends on channel structure and geometry of the micro channel obtained by the well-know deep reactive ion etching (DRIE) microtechnique. Instead of etching a tilted channel we made a double side deep reactive ion etching providing a tilted aperture which goes to deflect air flow like in a tilted channel case. For airflow control in aeronautic fields, one try to obtain an air jet making a 45° angle from the aircraft wing surface.

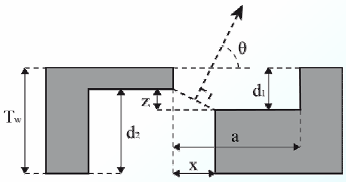


Without tilted air jets



With tilted air jets

Air Jet Angle Theory



Following dimensions of the fluidic device, we suppose air jet angle depends on the both d_1 and d_2 etching depths obtained by DRIE and the wafer thickness T_w.

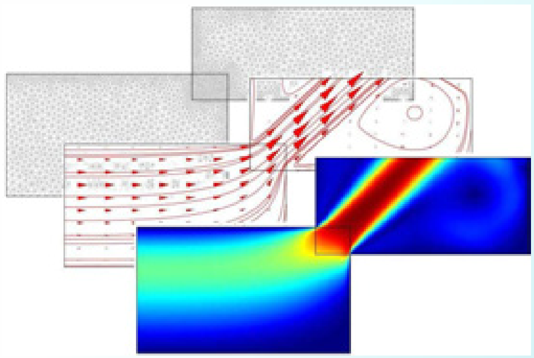
$$\theta = \arctan\left(\frac{x}{d_1 + d_2 - T_w}\right)$$

Air Jet Speed Theory

$$v_{out} = \sqrt{\frac{2}{\rho_{air}}\Delta P}$$

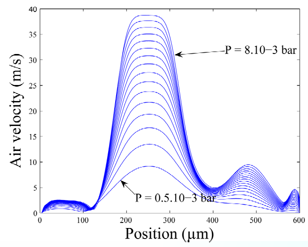
We can estimate micro air jet velocity using formula which comes from Pitot's tube experiment. This formula gives the average speed of the air jet according to the dynamic pressure at the entrance and the static pressure outside of the tube.

Simulations



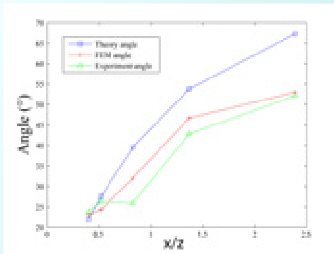
The fluid flow in the channel is described by the Navier-Stokes equations. In the area at the both etching junction (nozzle), the mesh size is extra fine in order to increase accuracy. At the outlet port, the air flows look like an air jet shape following a specific angle.

Results

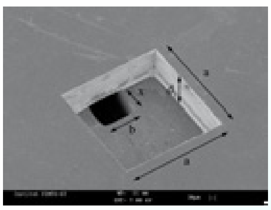


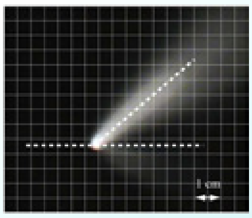
The most the inlet pressure is high the most the air jet speed is high. The slope of the jet does not seem to depend on the inlet pressure: the highest speed is always localized at the same position along the exhaust port.

Several shapes for the fluidic devices were tested to estimate the air jet angle in function of x/z which depends on the etching depths. Numerical results seem to correspond to the experimental results but not to our basic theory.



Experimental Results





Fluidic device is made using microtechniques of fabrication like DRIE.

Fluidic tests using smoke were conducted to observe and measure micro air jet angle.

Conclusion & Future Works

COMSOL simulations allow us to design a microfluidic device able to produce a specific air jet angle. We need x/z equal to 1.5 in order to obtain an 45° air jet angle.

In the future we want to test (with COMSOL simulations) their efficiency on the control of air flow close to an aircraft wing.

Contacts : Julien MALAPERT, Réda YAHIAOUI, Rabah ZEGGARI and Jean-François MANCEAU
(julien.malapert@femto-st.fr reda.yahiaoui@femto-st.fr)

INSTITUT CARNOT FEMTO-Innovation

Institut FEMTO-ST
32 avenue de l'Observatoire - 25044 BESANCON Cedex - France
www.femto-st.fr