Rapid advances in miniaturization and widening application areas of technology result in necessity of dissipating an increasing amount of heat from decreasing heat transfer areas at higher and higher temperature levels. This poses a challenge to science as effective cooling methods that would allow dissipating heat of high density over a wide range of operating temperatures need to be developed. Microsystems employing phase transition are a very beneficial solution as they are characterized by high values of heat transfer coefficient and spatial uniformity of the achieved cooling effect. Most of the research on flow boiling in microchannels has been conducted for saturation temperatures of up to 40ºC. The obtained results exhibit inconsistent trends which stems reaching definite conclusions on the mechanism responsible for heat transfer. Moreover, the knowledge acquired for temperatures below 40ºC cannot be directly used for modelling flow boiling at higher temperature levels as increasing saturation temperature often translates into significant changes of the thermophysical properties of the working fluids. High-accuracy models are based on the knowledge of the two-phase flow patterns in the channel as transition between the patterns coincides with the change of the dominant heat transfer mechanism. However, in the high-temperature range the number of available maps allowing identification of the flow pattern is limited and needs to be extended to microchannels.

Moreover, systems employing flow boiling are susceptible to instabilities. An effective solution is employing micro-orifices at the microchannel inlet. However, most of the experimental work was conducted for saturation temperatures of up to 40ºC. At higher temperatures an experimental verification of advisability of micro-orifice introduction and its impact on heat transfer dynamics is required.

Therefore, the objective of this project is identification of the dominant heat transfer mechanism and flow pattern during flow boiling in microchannels in the temperature range of 40-90ºC. The analyzed microchannels will be of rectangular shape and with the hydraulic diameter of 1 mm. The analysis will cover various inlet geometries – no inlet restrictions and rectangular micro-orifices.

Low-pressure refrigerant R245fa has been chosen as a working fluid due to its favorable properties over a wide range of operating temperatures. Flow pattern will be identified using high-speed images of channel operation. The identification of the dominant heat transfer mechanism will be conducted by analyzing the behavior of heat transfer coefficient with respect to mass and heat fluxes, vapor quality and saturation temperatures. The heat transfer coefficient will be determined on the basis of measured microchannel wall temperatures, working fluid temperatures and power of the supplied heat. As a consequence, development of flow pattern maps and identification of dominant heat transfer mechanism corresponding to a given pattern will be possible as a function of heat and mass fluxes and saturation temperature.

Results of this research project will extend the database of scientific knowledge on flow boiling in microchannels. They will provide information on the influence of micro-orifices on the heat transfer dynamics and stability of boiling systems. Thus, a better understanding of heat transfer phenomena during flow boiling in microchannels will be possible, as well as development of theoretical models for prediction of heat transfer coefficient covering a wide range of operating conditions and inlet geometries.

We believe that the knowledge acquired during this project will allow better control of micro-scale boiling systems and their implementation as an effective method for high heat flux cooling with low working fluid inventory required. The resulting reduction of investment and exploitation costs can contribute to sustainable development of many key fields of knowledge and technology e.g. electronics, communication, space and avionics.