The phenomenon of condensation is widely used in our everyday life for heating and cooling due to the heat transfer effect of condensation. It plays an essential role in facility heating with heat pumps, cooling refrigerators, or microelectronics cooling with heat pipes**.** Due to the high energy efficiency of **the condensation, it is also useful for heat transfer during technological processes like reflow soldering, which is the primary step of Surface Mounting Technology (SMT). Nowadays, SMT is the most used and most important assembling technology in the electronics industry; most of our electronic circuits are prepared by SMT.** It has three main steps, solder paste deposition onto the solder pads of a Printed Circuit Board (PCB); component placement onto solder deposits, and finally, reflow soldering, which means heating up the whole assembly over the melting point of the solder alloy which forms a mechanical and electrical joint between the terminals of the components and pads of the PCB. SMT technology faces serious challenges: miniaturization (smaller and smaller components); increase of complexity (more and more components); increasing reliability demands) and increasing quality demands ("zero defects manufacturing"). These cause a high need for novel soldering technologies.

When condensation heat is used for heating during reflow soldering, then the technology is called Vapour Phase Soldering (VPS). During the VPS process, a special heat transfer fluid is heated at the bottom of a tank. When the fluid is heated up to its boiling point, a vapour blanket begins developing above its surface. The boiling continues, and the vapour blanket starts to fill up the tank. When the vapour blanket is ready for soldering, the assembly is immersed into the vapour, and consequentially a condensate layer forms on the colder surface of the PCB and heats it up. After a given period of time, the assembly is lifted out of the tank in order to cool down, enabling the melted solder alloy to solidify. From the point of energy consumption, the **VPS is an environmentally friendly reflow soldering technology** since it has the best energy efficiency among the reflow soldering techniques. Therefore it is still considered a promising alternative to convection and infrared reflow methods in the electronics industry. **However, the heat transfer of the VPS technology differs much from the convection or infrared technologies, and up to now, only limited research has dealt with the thermal aspects of the VPS process.**

Basically, the solder pastes – applied for SMT –are colloid suspensions that contain solder balls in a special "thinner" in 50-50 vol%. The special thinner is a so-called flux that cleans the soldered surfaces and enhances the wetting properties of the solder. Next to the applied soldering technology, the other important aspect of producing proper solder joints is the applied solder alloy. The most novel solution for **improving the properties of the solder alloys is the use of ceramic nano-particles (NPs),** like TiO_2, Si_3Ni_4, SiC, ZnO etc., in the solder paste, **which results in composite solder joints**. The NPs change the thermal and mechanical parameters of the solder alloys via grain refinement and the modified grain boundary/interfacial characteristics.

The scientific objective is to investigate the heat transfer effects on the formation of solder joints microstructure during the Vapour Phase Soldering (VPS) process by numerical simulations and metallurgical studies. The main focus of the project is the novel nano-composite solder alloys where the incorporation of the applied nano-particles (NPs) changes the thermodynamic equilibrium of the system. **The scientific hypothesis is** that the different settings of the VPS system may result in considerable heat transfer differences, which causes significant microstructural differences in the nano-composite solder joints affecting the quality and reliability of the joints**.** However, in possession of the expected results, the VPS technique could be optimized for the novel nano-composite solder alloys. In the first step, a numerical modell will be established on the level of the solder joints to investigate the heat transfer mechanisms during the VPS in the case of different system settings, as the most affecting factor on the forming of the solder joint microstructure. The second step is to perform metallurgical studies on nano-composite solder joints (intermetallic layer formation and grain structure) prepared by different heat transfer coefficients, verifying the hypothesis about the influence of heat transfer on the joint microstructure. It means preparing metallurgical cross-sections from the solder joints; characterizing the microstructures by optical microscopy and Scanning Electron Microscopy; identifying the different phases by X-ray Energy Dispersive Spectroscopy, and investigating the grain structures by Transmission Electron Microscopy and Selected area Electron Diffraction.

Overgrowing miniaturization of electronic devices and the harsher and harsher working conditions require more and more precise soldering technologies and soldering materials. Furthermore, the sustainability of the technology is also an essential question due to the way to carbon neutrality aspiration of the EU. Almost all electronic devices go through some kind of soldering step during production, so soldering failures, including the material's defects, are serious problems that may cause considerable reliability risks during the operation of the devices. **The expected result of the project will be an environmentally friendly, appropriately set soldering technology for the novel nano-composite solder alloys. It will allow getting knowledge about the incorporation of the different NPs into the solder matrix of the joints; the microstructural changes of the solder joints due to the NPs; and the mechanical, electrical, and thermal effects of the incorporated NPs on the solder joints.** This theoretical knowledge will enormously help the further development of soft soldering technology.