Fraunhofer



# Pulsating heat pipes
## Additively manufactured

### High-performance, lightweight, and easy to integrate thanks to 3D printing

*Straight from the 3D printer: Additively manufactured pulsating heat pipes, made from a lightweight aluminum alloy, offer great design flexibility and can be integrated in a space-saving manner.*

With increasing power and packing density of electronic components, the amount of waste heat generated in confined space rises considerably. This can result in temperatures high enough to cause defects in electronic devices. Pulsating heat pipes (PHPs) dissipate heat very effectively while taking up minimal space. Additive manufacturing offers many advantages in the production of PHPs.

### Slim design for high heat transfer

Pulsating heat pipes (PHPs) can effectively solve many heat dissipation problems. Thanks to their slim design, PHPs dissipate high heat loads in a small space.

Unlike standard heat pipes, in which the fluid typically flows back through a wick structure, PHPs consist of many thin, meandering channels containing alternating liquid and vapor segments. The temperature and pressure differences between the hot and cold sides cause these segments to move in a continuous pulsating motion. This allows fluid and heat to be transported highly efficiently from the heat source to the cold side. Typical applications for PHPs include power electronics and aerospace.

### Fast, flexible, and cost-efficient PHP manufacturing

In conventional PHP manufacturing, channels are typically machined into base plates, and the components are then joined. This process requires a high degree of precision, especially regarding the necessary vacuum tightness, as well as significant manufacturing effort. Additive manufacturing enables the base body to be produced as a single-piece (monolithic) component that incorporates the channels. This shortens processing times, reduces the number of manufacturing steps, and, in many cases, saves costs.

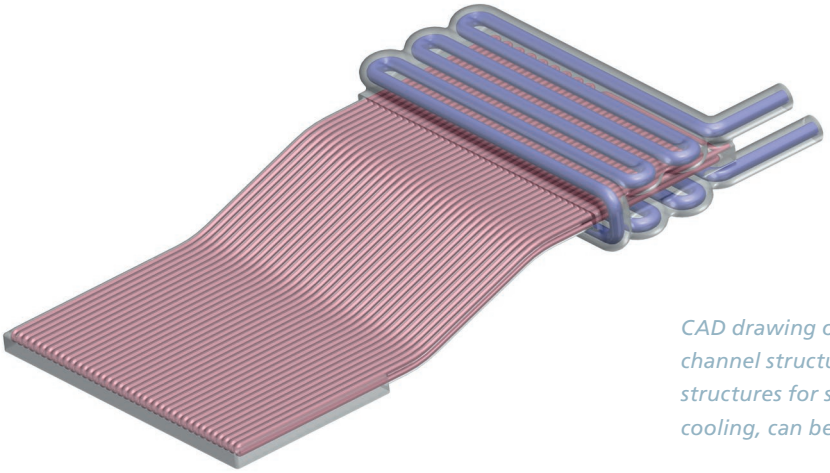
### High level of design freedom and improved integration

A key advantage of additive manufacturing is its high level of geometric freedom. Additively

### Our offer

We develop custom PHP solutions for applications with high thermal requirements, limited installation space, and low weight.

Feel free to contact us!



*CAD drawing of a PHP with a multi-layer fluid channel structure (red). Additional channel structures for secondary cooling, such as water cooling, can be directly integrated as an option.*

manufactured PHPs can be produced with application-specific geometries, curves, or bends and can be tailored to fit the installation space. They can also be integrated directly into housings, structural components, or cooling systems. This results in fewer or no additional material and joint transitions, thereby ensuring improved thermal coupling and particularly space-efficient integration.

## High heat transfer capacity

Additive manufacturing allows for the production of multilayer fluid channel structures with minimal effort. These structures can dissipate heat from components with heat flux densities of several hundred W/cm² or more.

## Lightweight construction for demanding applications

Additive manufacturing allows for the production of light-weight PHP designs, which is particularly beneficial for the aerospace industry. It allows the mass of the base body to be reduced to the necessary minimum without requiring extra effort during manufacturing. Additionally, additive manufactur-ing simplifies the production of aluminum alloy parts, which present unique challenges with traditional brazing and welding processes.

## High-performance demonstrator

The first copper PHP demonstrators manufactured using additive manufacturing at Fraunhofer IWU and Fraunhofer IPM show exceptional performance. With an effective channel area measuring approximately 170 mm × 90 mm, a height of just 2.8 mm, and a weight of around 150 g, preliminary tests in vertical and horizontal orientations yielded a thermal power dissipation capacity of about 1,200 W. Extrapolating this data suggests that a heat dissipation of several kilowatts is theore-tically possible with the same PHP. However, the performance potential depends heavily on the specific design, installation conditions, and connection to the heat source and heat sink.

## Our services

- Feasibility studies and application evaluation
- Customized design and engineering
- Development and manufacturing of additively manufactured demonstrators
- Filling with working fluid and quality control
- Thermal characterization and performance measurement
- Production support: from demonstrators to mass production

Are you considering using additively manufactured pulsating heat pipes for your application? Contact us, and we will work with you to develop and validate a solution tailored to your requirements.

## Contact

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**exhibits overview**

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