

# Micro Heat-pipe with 1-mm Thickness

## 1. INTRODUCTION

As computers improve in performance and speed, the heat generated by the micro processing unit (MPU) increases rapidly, making heat dissipating measures indispensable. In particular, notebook PCs where heat dissipation poses a serious problem due to the small packaging volume, heat dissipation technology has become one of the key technologies. Micro heat-pipe (hereafter denoted as  $\mu$ HP) is capable of coping with this problem, and has been in practical use since 1995.

In the MPU industry, while MPUs with extreme heat generation are marketed for high-end applications, power-saving type MPUs with small heat generation have also been developed.

$\mu$ HP heat-sinks used in notebook PCs equipped with such power-saving MPUs are generally required to be low in profile in order to improve portability. Thus, a  $\mu$ HP having a thickness as small as 1 mm --the thinnest in the world among practical  $\mu$ HPs-- has been developed to realize such heat-sinks. Below will be introduced the structure and performance of 1-mm thick  $\mu$ HP.

## 2. STRUCTURE

A  $\mu$ HP for room temperature use is normally comprised of a copper container and a working fluid of water. The working fluid of water has a large amount of latent heat providing the  $\mu$ HP with a great deal of heat transfer rate. Heat transfer is effected by the working fluid, in which the water vapor used in heat transfer is cooled down to liquid water at the heat radiation portion of the  $\mu$ HP, making it necessary to return the liquid to the heat receiving portion by the help of capillary force arising from the wick. The wick structure may include grooved copper tubes, insertion of mesh or fiber within the container and sintering of metals resulting in porous materials.

Figure 1 shows the structure of this  $\mu$ HP with a thickness of 1 mm. A mesh constituting the wick is configured in the center or sides of a flattened copper container, featuring the isolation of the passage for vaporized working fluid from that for returning the liquefied working fluid. Such a structure ensures a passage for the vaporized working fluid, permitting sufficient circulation of water and vapor even when the container is flattened down to a

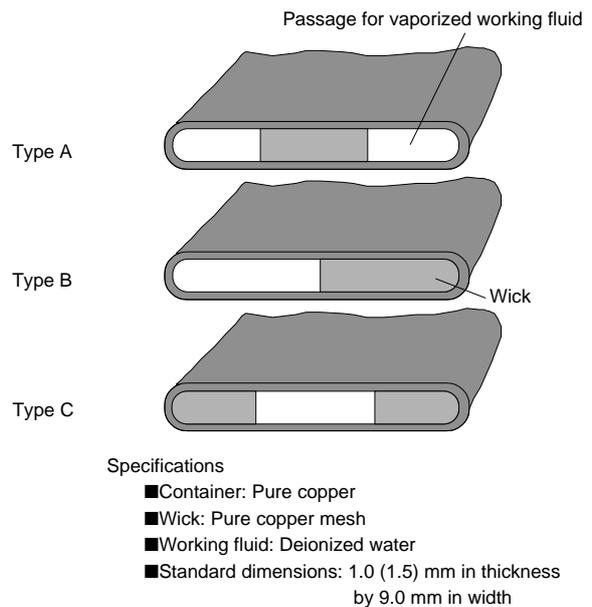


Figure 1 Structure of  $\mu$ HP with 1-mm thickness.

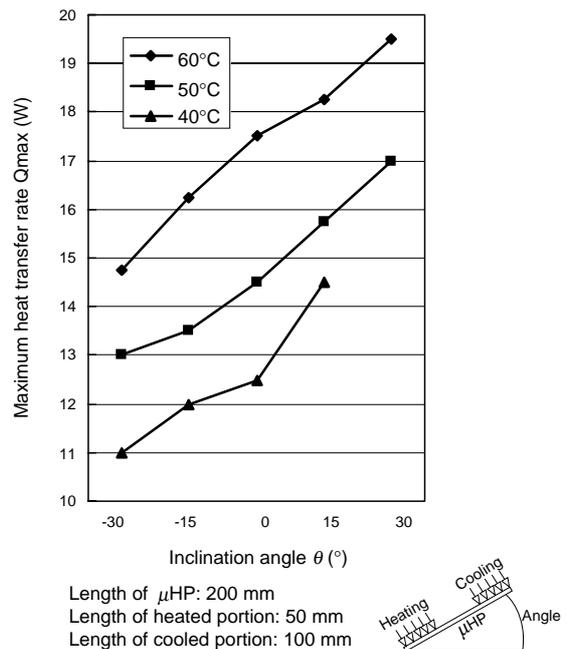


Figure 2 Maximum heat transfer rate of  $\mu$ HP with 1-mm thickness.

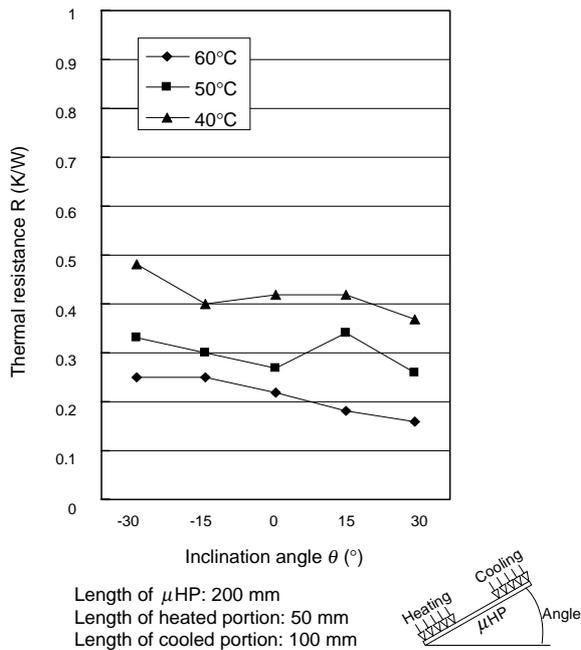
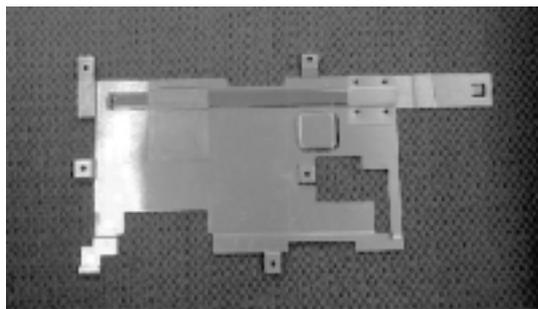


Figure 3 Thermal resistance of  $\mu$ HP with 1-mm thickness.



- Features
- Small thickness of 1 mm
  - Applicable to bending process
  - Large heat transfer rate
  - Direct mounting to heat-generating devices permitted

Figure 4 An application example of  $\mu$ HP with 1-mm thickness.

thickness of 1 mm, thereby carrying out an effective function as a heat pipe.

### 3. PERFORMANCE

Figure 2 shows the characteristic curve for maximum heat transfer rate of this 1-mm thick  $\mu$ HP, which increases as the working temperature increases. The working temperature in a notebook PC equipped with a heat-pipe normally rises to 60–80°C. At this working temperature, the maximum heat transfer rate of this 1-mm thick  $\mu$ HP is known to be 18 W or more, so that it is estimated that a heat amount of as much as about 35 W generated by an MPU can be satisfactorily dissipated by employing a heat-sink provided with a fan, a heat-radiating plate or a die-cast radiator.

Figure 3 shows the characteristic curve for thermal resistance of this 1-mm thick  $\mu$ HP. When installed on a notebook PC, a heat-pipe is required to be lower in thermal resistance the higher the working temperature. This 1-mm thick  $\mu$ HP is shown to have lower thermal resistances at higher working temperatures, thus sufficiently guaranteeing practical applications.

Figure 4 shows a heat-sink, i.e., an application example of this 1-mm thick  $\mu$ HP, which successfully eliminates a fan to dissipate the heat generated by a low heat generation MPU of about 8 W.

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