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Experimental Study of Nucleate Pool Boiling Heat Transfer Characteristics on Laser-Processed Copper Surfaces of Different Patterns

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Abstract : With the fast growth of integrated circuits and the trend towards making electronic devices smaller, the heat dissipation load of electronic devices has continued to go over the limit. The high heat flux element would not only harm the operation and lifetime of the equipment but would also impede the performance upgrade brought about by the iteration of technological updates, which would have a direct negative impact on the economic and production cost benefits of rising industries. Hence, in high-tech industries like radar, information and communication, electromagnetic power, and aerospace, the development and implementation of effective heat dissipation technologies were urgently required. Pool boiling is favored over other cooling methods because of its capacity to dissipate a high heat flux at a low wall superheat without the usage of mechanical components. Enhancing the pool boiling performance by increasing the heat transfer coefficient via surface modification techniques has received a lot of attention. There are several surface modification methods feasible today, but the stability and durability of surface modification are the greatest priority. Thus, laser machining is an interesting choice for surface modification due to its low production cost, high scalability, and repeatability. In this study, different patterns of laser-processed copper surfaces are fabricated to investigate the nucleate pool boiling heat transfer performance of distilled water. The investigation showed that there is a significant enhancement in the pool boiling heat transfer performance of the laser-processed surface compared to the reference surface due to the notable increase in nucleation frequency and nucleation site density. It was discovered that the heat transfer coefficients increased when both the surface area ratio and the ratio of peak-to-valley height of the microstructure were raised. It is believed that the development of microstructures on the surface as a result of laser processing is the primary factor in the enhancement of heat transfer performance.

Keywords : heat transfer coefficient, laser processing, micro structured surface, pool boiling
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