Supporting Information
Rational Micro-Nano Structuring for Thin Film Evaporation

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Optimal porosity for thin-film evaporation

The interfacial heat flux for different micro-structures as a function of porosity of the structures are shown in Fig. S1. The porosity in these structures is defined as the ratio of void volume to the total volume in each model structure.

The height of the developed micro-structures is examined with scanning electron microscopy (SEM) and are shown in Fig. S2.

2D heat transfer to the liquid-vapor interface

The mass flux normal to the liquid-vapor interface is given by the Hertz-Knudsen equation. To determine this mass flux, one needs to determine the normal heat flux to the liquid-

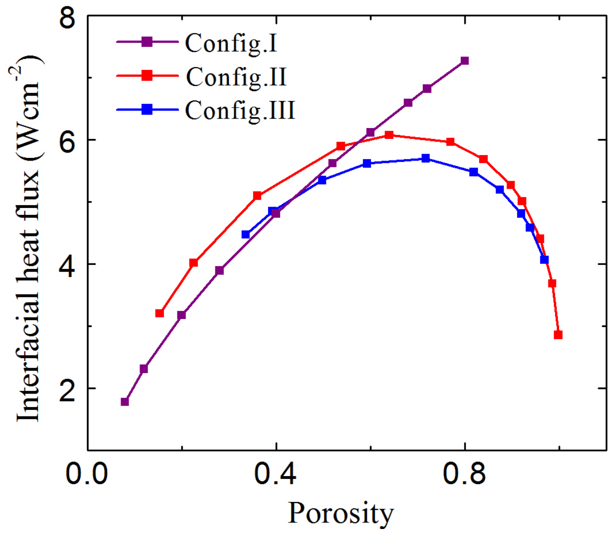

Figure S1: The interfacial heat flux in the micro-structures as a function of porosity of the structures is shown. For configuration II and III, there are optimal porosity which maximizes the interfacial heat flux.

vapor interface. The heat transfer to the liquid-vapor interface is two-dimensional; one from the pillars, $\dot{q}_y$, and one from bottom of the micro-structure, $\dot{q}_z$, Fig. S3. We calculate the projection of these heat fluxes in the normal direction to the liquid-vapor interface through turning angle, α.

$$\dot{q}_l = \dot{q}_y \sin\alpha + \dot{q}_z \cos\alpha \tag{1}$$

where $\tan\alpha = dy/dz$ at each (y,z) coordinate along the liquid-vapor interface. Once we replace the values of $\dot{q}_y$ and $\dot{q}_z$ in the above equation through Fourier equation, one finds

$$\dot{q}_l = \kappa_l (T_s - T_{lv}) \left(\frac{1}{r-y} \sin\alpha + \frac{1}{H + z(y)} \cos\alpha \right) \tag{2}$$

We should add that in the Hertz-Knudsen model of evaporation, the accommodation coefficient appears in a multiplier function in the local evaporative mass flux and does not have any dependence on r,

$$\dot{m} \propto \frac{2\sigma}{2-\sigma} f(r) \tag{3}$$

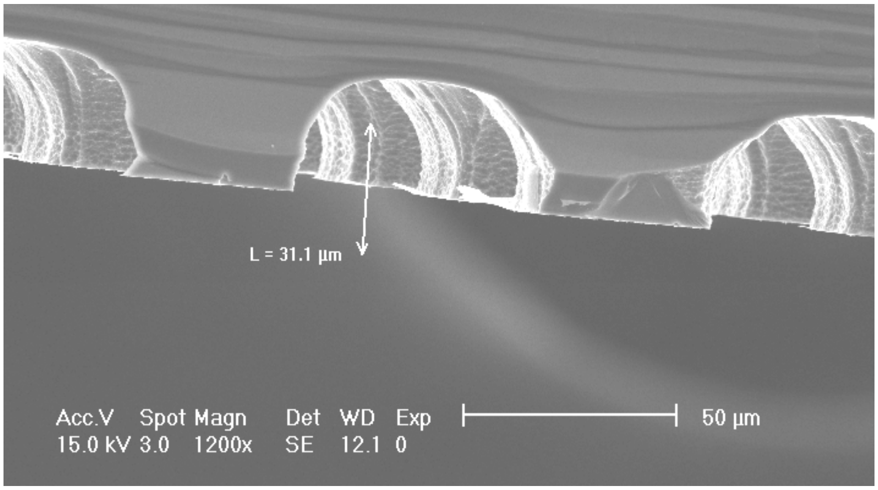

Figure S2: The height of the pillars are examined with the Scanning Electron Microscope (SEM) and is approximately 30μm. For this measurement, a sample of micro structures is cut and assembled vertically in the SEM.

where r denotes the radial coordinate between the pillars. Since the optimal width-to-spacing ratio is a direct consequence of $f(r)$ and total area of evaporation, it will be unaffected with different values of accommodation coefficient. We determined the optimal width-to-spacing ratio for different values of accommodation coefficient and this optimal value is unchanged.

Experimental procedures

The experimental setup includes a fluid dispensing system, which continuously provides fluid to the micro-structure; a controlled flexible heater with diameter of 2 cm attached to the sample and a power system to adjust the temperature of the heater and control superheat. The working fluid in this experimental setup is Isopropyl alcohol (IPA). The microstructure is placed under the fluid dispensing system and simultaneously heated. The fluid from the dispensing system infiltrates to the structures and comes back to the surface by the capillary force for thin film evaporation. The dispensing rate is finely tuned to reach to a steady-state evaporation condition. Each experiment was performed for more than 30 min and the

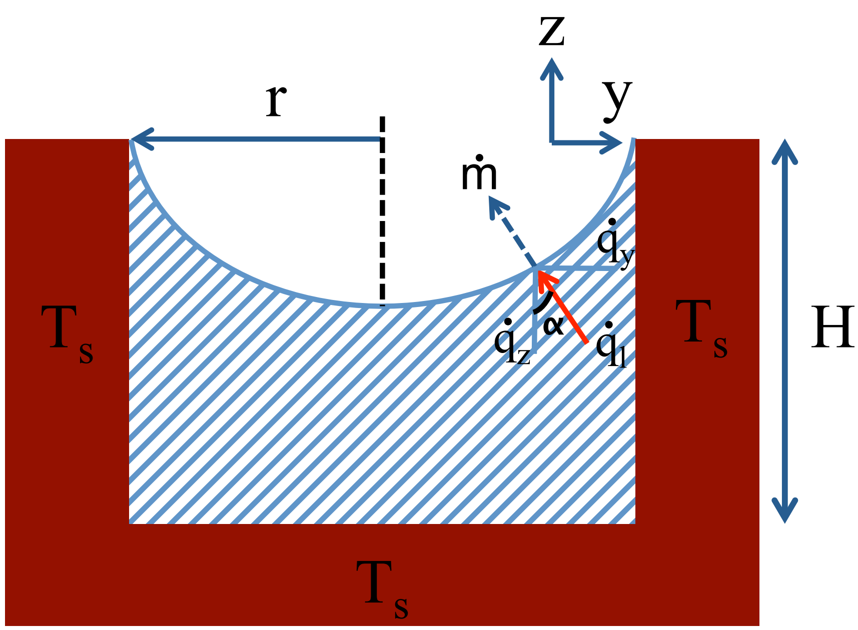

Figure S3: The normal heat flux to the liquid-vapor interface is shown. The normal heat flux comprises of heat flux by the pillars and the heat flux by the bottom substrate.

fluctuations in the evaporative mass flux was less than 1%. Once the steady-state condition is achieved, the interfacial heat flux was calculated through fluid dispensing rate, enthalpy of phase change, and the area of thin-film evaporation.

Error in the measured interfacial heat flux

The interfacial heat flux is measured through energy equation

$$\dot{q} = (\dot{m} \times h_{fg})/A \tag{4}$$

where $\dot{m}$ denote the evaporative mass flux in the steady state evaporation, h_{fg} enthalpy of liquid-vapor phase change and A the area of thin film evaporation. The error in the

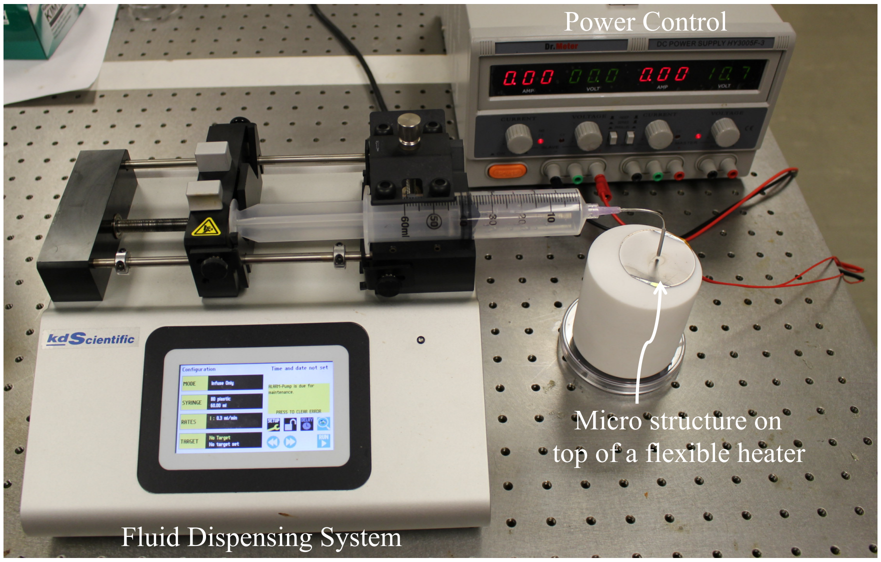

Figure S4: The experimental setup for thin film evaporation studies are shown. The setup includes a fluid dispensing system, a power system attached to a flexible heater that control the temperature of the micro-structure, and the microstructure. The setup provides the opportunity to measure the interfacial heat flux by the micro/nano structures in a steady-state condition.

interfacial heat flux $\delta\dot{q}$ is written as

$$\frac{\delta\dot{q}}{\dot{q}} = \frac{\delta\dot{m}}{\dot{m}} + \frac{\delta A}{A} \tag{5}$$

Where δ denotes the error in the measured values. Note that the error in the values of h_{fg} is so small and negligible. Through the error in the mass injection rate by the syringe pump and the error in the determined surface area of thin film evaporation (ImageJ analysis), we determined the error in the interfacial heat flux.