

## CLAIMS

What is claimed as new and desired to be protected by Letters Patent of the United States is:

1. A system, comprising:
  - a nanophotonics-enabled solar distillation system;
  - a dynamic heat recovery (HX) system,
  - at least two counter-flowing liquid streams separated by at least a spectrum absorbing material,
  - wherein the at least one counter-flowing liquid streams comprises a feed stream and a distillate stream, and
  - wherein the spectrum absorbing material is hydrophobic, light-absorbing, and photothermal.
2. The system according to any one of the preceding claims, wherein the distillate stream is brought into a thermal contact with the feed stream through a heat exchanger.
3. The system according to any one of the preceding claims, wherein a flow rate of the feed stream and a flow rate of the distillate stream are adjusted independently.
4. The system according to any one of the preceding claims, wherein a maximum flux is achieved when the flow rate of the feed stream and the flow rate of the distillate stream are equal.
5. The system according to any one of the preceding claims, further comprising a light intensity dependent flow controller configured to control the flow of the feed stream as a function of light incident on the system.
6. A method, comprising:
  - combining a nanophotonics-enabled solar distillation system and a dynamic heat recovery system as a coupled system when at least two counter-flowing liquid streams separated by a spectrum absorbing material comprising a feed stream and a distillate stream are matched;

recycling a heat energy into the feed stream by the coupled system of the nanophotonics-enabled solar distillation system and the dynamic heat recovery system; and

enabling an operation, by the coupled system of the nanophotonics-enabled solar distillation system and the dynamic heat recovery system, when no light is incident on the coupled system.

7. The method according to claim 6, wherein the spectrum absorbing material is a membrane.
8. The method according to any of claims 6 and 7, wherein a temperature gradient across the spectrum absorbing material causes a vapor to traverse from the feed stream to the distillate stream.
9. The method according to any one of claims 6-8, wherein the distillate stream is brought into a thermal contact with the feed stream through a heat exchanger.
10. The method according to any one of claims 6-9, further comprising adjusting a flow rate of the feed stream and a flow rate of the distillate stream independently.
11. The method according to any one of claims 6-10, further comprising equalizing the flow rate of the feed stream and the flow rate of the distillate stream to achieve a maximum flux.
12. The method according to any one of claims 6-12, further comprising controlling a flow rate of the feed stream and a flow rate of the distillate stream as a function of light incident on the coupled system.
13. A method, comprising:
  - providing a resonant thermal oscillator in a thermofluidic system, the thermofluidic system comprising:
    - at least two counter-flowing liquid streams separated by at least a spectrum absorbing material,
    - wherein the spectrum absorbing material is hydrophobic, light-absorbing, and photothermal; and

adjusting a flow rate in at least one of the counter-flowing liquid streams to maximize heat transfer between the at least two counter-flowing liquid streams.

14. The method of claim 13, wherein the at least one counter-flowing liquid streams comprises a feed stream and a distillate stream.
15. The method of claim 13, further comprising using the thermofluidic system as a thermal battery.
16. The method of claim 13, further comprising using the thermofluidic system as a thermochemical reactor, wherein the at least two counter-flowing liquid streams comprise at least one chemical precursor to a chemical reaction in the resonant thermal oscillator.