DISTRIBUTED AND SELF-ADAPTIVE MICROFLUIDIC CELL COOLING FOR CPV DENSE ARRAY RECEIVERS

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STREAMS

Smart Technologies for eneRgy Efficient Active cooling in Advanced Microelectronic Systems

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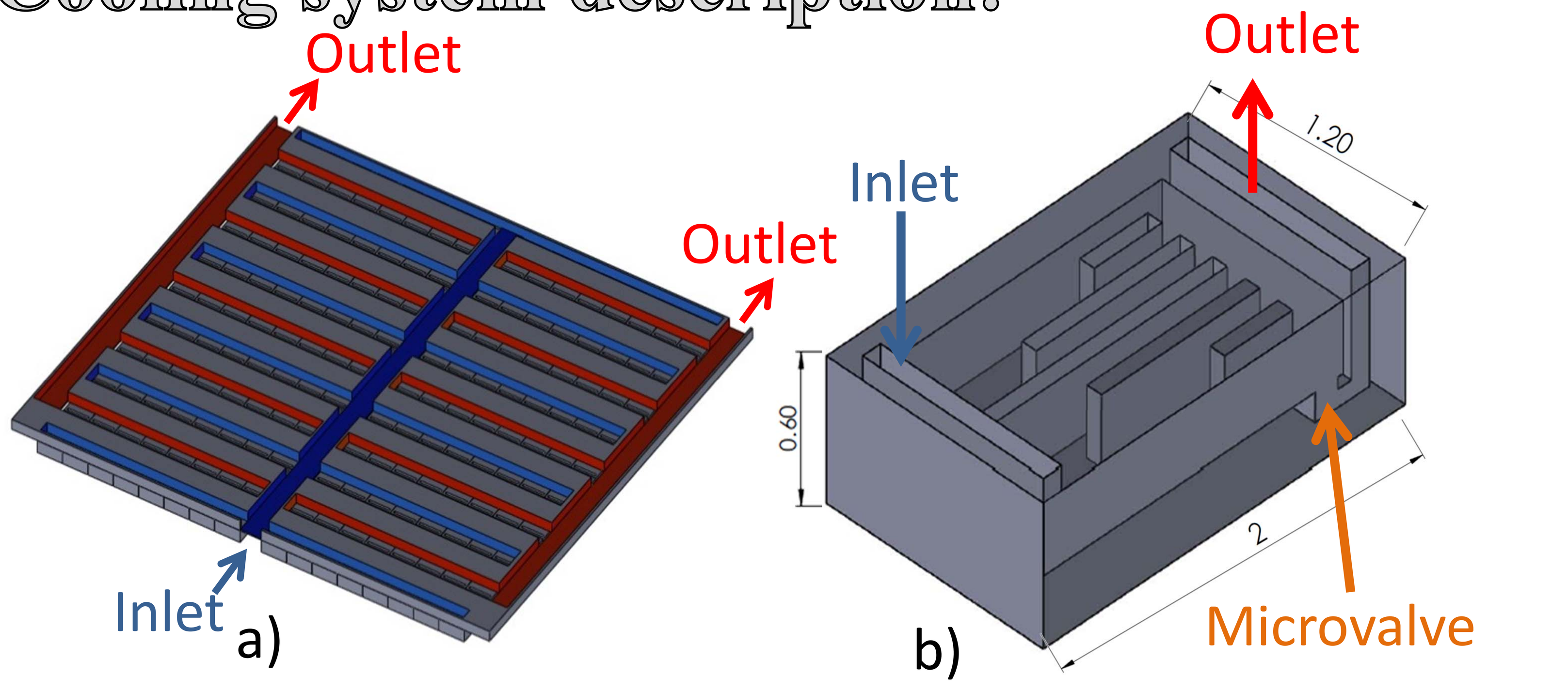
Introduction:

Cooling devices for dense array CPV receivers require high compactness, low average temperature and high temperature uniformity to avoid mismatch losses.

This study compares the impact of a conventional microchannel cooling device with the **matrix of microfluidic cells with individually variable coolant flow rate** when applied to a **CPV receiver** formed by a matrix of PV cells (6 strings of 8 in series) with identical **irradiance distribution** and **average temperature**.

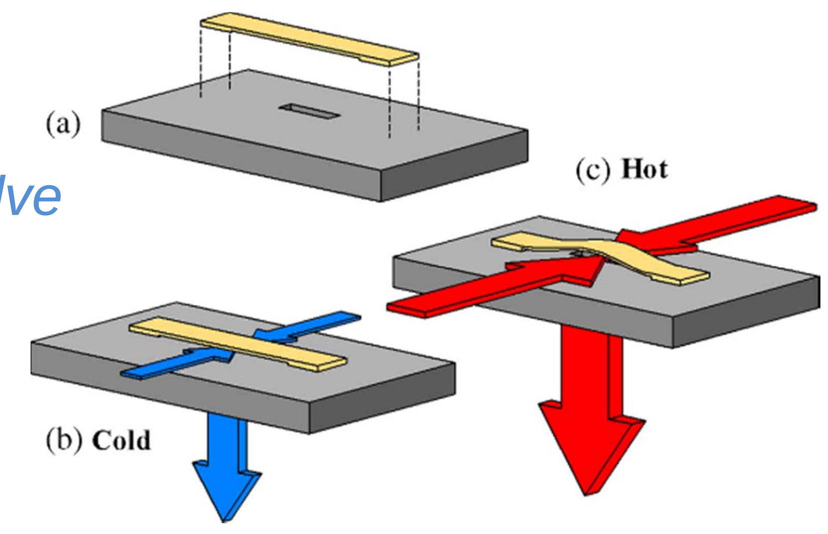
Cooling CPV Requirements	Solutions
High compactness	Liquid cooling
Low thermal resistance coefficient (R<10-4 Km2/W)	Microchannels based geometry
High temperature uniformity under non-uniform and time dependent heat load scenarios	**Matrix of microfluidic cells with individually variable coolant flow rate**

Cooling system description:



a) Cell matrix and distributor b) Microfluidic cell (dimensions in mm)

Temperature driven Microvalve
a) Location
b) cold position
c) hot position

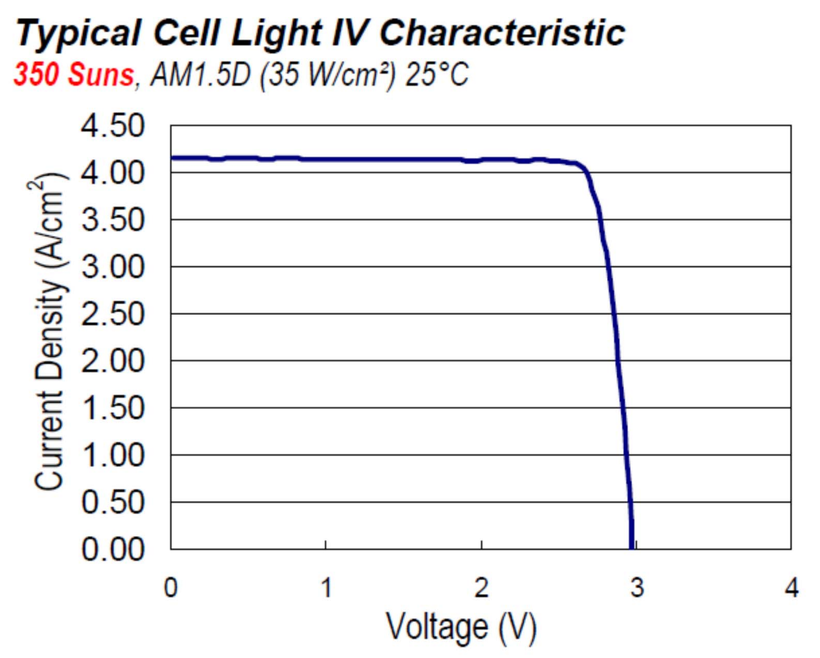


Performance in microelectronic application (previous studies)

$$P_{Pump}(Microfluidic\ cell) = 10.8\,\% \cdot P_{Pump}\ (Microchannel)$$

$$\Delta T(Microfluidic\ cell) \approx \frac{\Delta T(Microchannel)}{10}$$

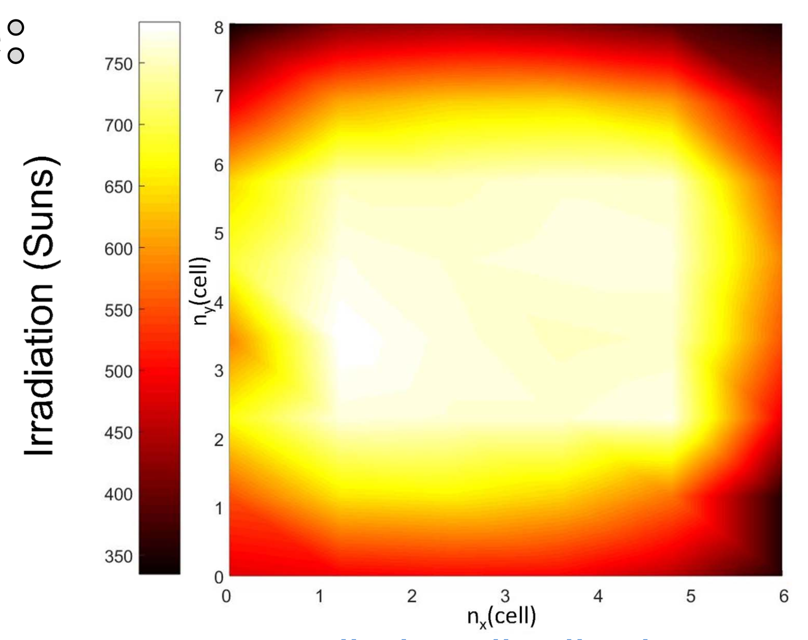
Impact of the cooling device on the CPV performance:



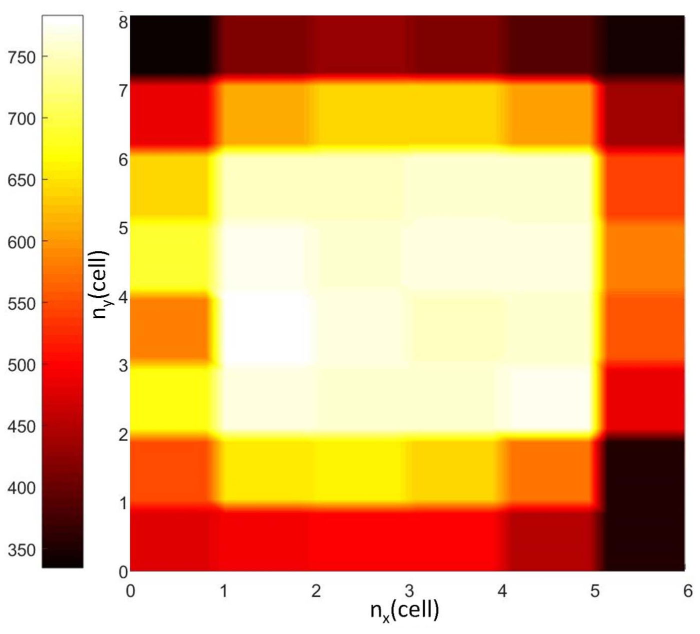
IV curve (Spectrolab)
6 strings of 8 PV cells in serie

Typical Cell Electrical Parameters
350 Suns, AM1.5D (37.2 W/cm²) 25°C

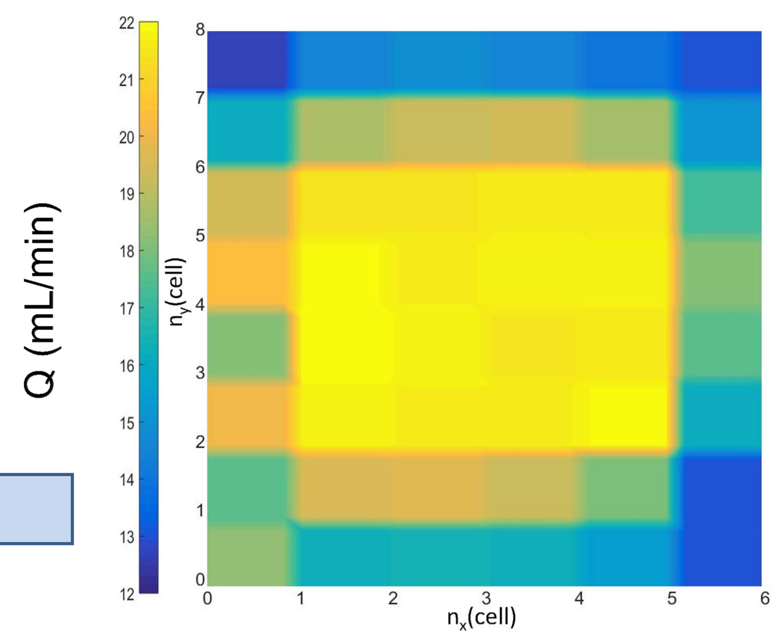
J_{sc}= 4.14 A/cm²	J_{mp}= 4.05 A/cm²
V_{oc}= 2.97 V	V_{mp}= 2.64 V
P_{mp}= 10.68 W/cm²	Cff = 86.9 %
Efficiency = 30.5 %	



Irradiation distribution

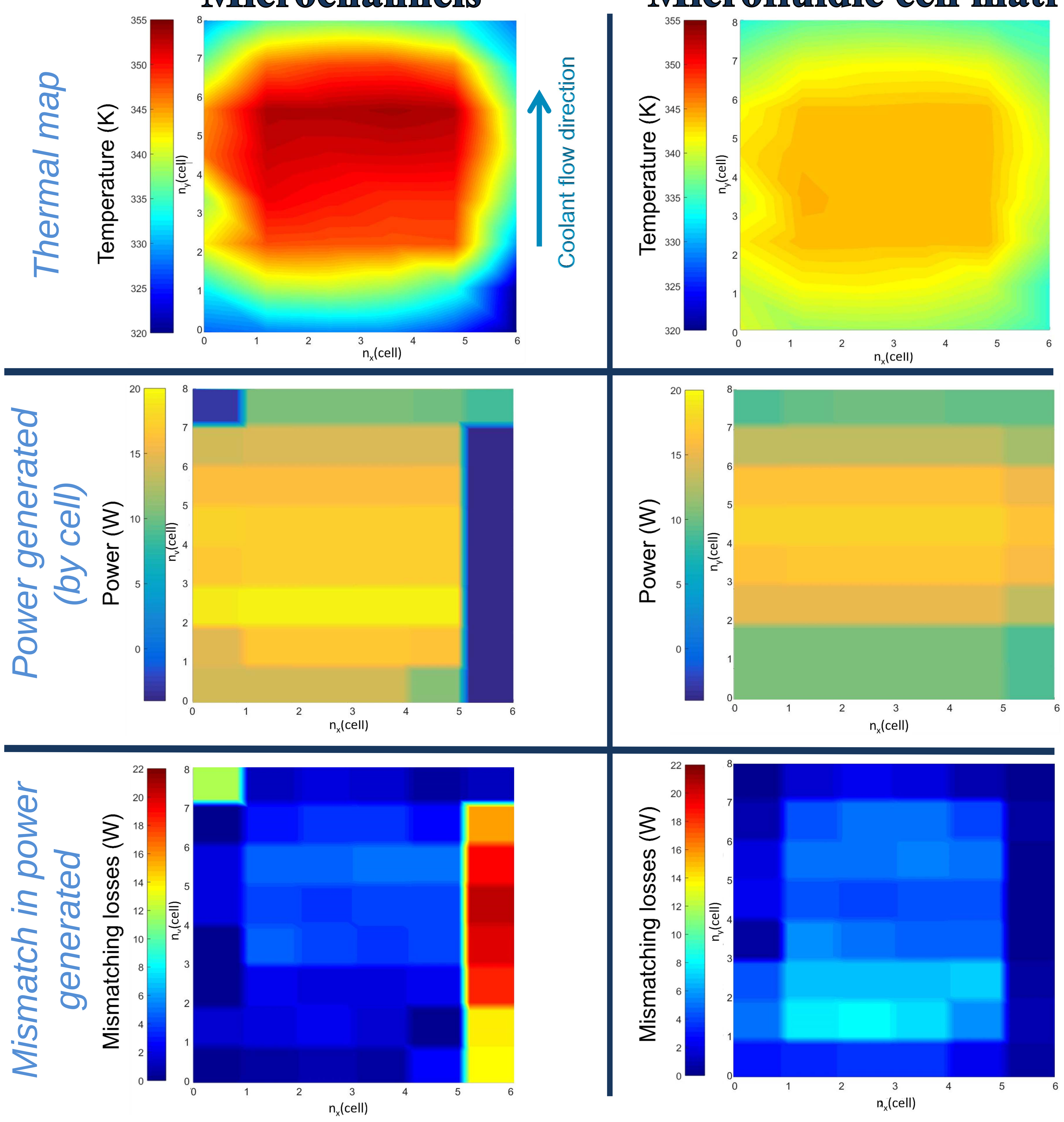


Irradiation distribution, averaged by PV cell



Cell flow rate distribution

Microchannels | **Microfluidic cell matrix**



CONCLUSIONS:

- The advances in Concentration PV cell technology imply the increase of the Fill Factor and, therefore, lead to higher impacts of the mismatch losses associated to the CPV receiver's temperature non uniformities.
- The matrix of microfluidic cells with individually variable coolant flow rate is able to provide high temperature uniformities under time dependent and non uniform heat loads.
- **Global power generation of microchannels and microfluidic cells** are respectively **72.6%** and **79.7%** with respect to the sum of the ideal isolated cells production at the same illumination and temperature conditions.
- **Power generation** applying the microfluidic cells cooling device is **9.7% higher** than the one with conventional microchannel technology (at equal average temperature).

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