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Pressure evolution in a 3D microcavities array

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A microcavity array is a set of volumes in the micrometer range. A 3D microcavities array is a 3D arrangement of such small cavities. It may have volumes equally spaced in an ordered pattern or not. Good examples of these materials are foams, sponges and cork. Although the motivation for this work came from the need to understand the pressure evolution in cork cells when subjected to vacuum or to pressure, the proposed approach is valid for any kind of 3D arrays or to 3D RC (resistor capacitor) networks, as it will be shown.
The purpose of this work is, first, to achieve a quantitative description of the flow from a 3D microcavities' array versus time when subjected to a pressure change, and secondly, to describe the pressure evolution at any point of the inner volume.
The problem of pumping a 3D array of n microcavities is equivalent to discharging (or charging) of a 3D array of n capacitors interconnected by resistors, having all resistors at the borders shunted and connected to a power supply. The use of electrical equivalents to describe gas flow and pressure evolution is convenient because there are many options to simulate electrical circuits. Since the gas flow inside a cork is in the molecular regime, the conductance is pressure independent and the inverse of the electrical resistance is the direct equivalent to the flow conductance. This is not the case for other regimes where conductance is a function of pressure. The flow rate is the equivalent to the electrical current and pressure is the equivalent to the electrical potential. However, when the amount of cells is very large the system becomes virtually impossible of simulation. E.g. one cork stopper has about 1E9 cells. Above 1E4 nodes, the simulation performed by electrical simulators requires many hours on a PC. Therefore, the problem was solved by finding equivalent systems, easier and faster to simulate. Authors will show and discuss the results achieved using this approach.
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