Thermal characterisation and management of stacked 3-D integrated circuits

Summer internship project description

Background. The demand for ever increasing degree of integration and minituarisation in modern integrated circuits (ICs) is driven both by consumers' demand for more sophisticated portable and mobile devices catering for the incoming Internet of Thigs applications and by the push towards exascale computing systems required for modelling and simulation of challenging problems at the forefront of science and engineering. Modern ICs cannot follow a well-established path of ever increasing minituarisation and package density mainly due to the thermal issues. A disruptive technology which offers a way forward is the 3-D integration, where potentially heterogeneous ICs are stacked and interconnected with vertical wires. Such approach offers significant advantages compared to standard 2-D ICs, by reducing both the interconnect delay (through shortening the length of signal/power lines) and power consumption. At the same time stacked technology increases heat dissipation in the IC and alters significantly the heat release paths compared to standard 2-D chips. This is the reason that the standard IC cooling mechanisms, such as air cooling with a heat sink and fins, are insufficient in 3-D stacks.

In such circumstances, the design of functionally and thermally reliable 3-D ICs is a challenging problem, and thermal verification needs to be performed repeatedly as a part of the design process. A standard approach to thermal modelling in the Computer-Aided Design community is to invoke the electro-thermal duality, which casts the problem of heat distribution in a material body as an electric resistor circuit. The advantage of this approach is in its simplicity and computational speed, but at the expense of accuracy. 3-D ICs introduce significant material heterogeneities and non-linearities in model parameters, rendering the electro-thermal models difficult to use. An alternative is to apply accurate, but computationally more expensive physical model based on the heat equation. Such approach is adopted in Manchester Thermal Analyzer (MTA), an academic thermal modelling tool for ICs, developed in the School of Computer Science. The initial version of the tool was publicly released in 2017. Since then the model has been significantly upgraded to account for non-linear effects and performance optimisation of the code was performed.

Post description. We are seeking an ambitious and motivated undergraduate student to bring the current version of the MTA simulator into the shape that can be released for public use. The post is advertised for a fixed term of 8 weeks, starting on 1 June 2019, or as soon as possible thereafter. The successful candidate will work on two subtasks:

- To merge the new version of the code, optimised for performance and including the non-linear model and the old version of the code. A number of tests and verifications need to be performed in this context to verify numerical accuracy, reliability, and parallel performance of the new model.
- To finish the work on the time integration methods for the non-linear model. This part involves development of adaptive predictor-corrector schemes for the solution of large systems of initial value problems. Training in this methodology will be provided during the course of the project.

The candidate will work with Dr Milan Mihajlovic, with involvement from Dr Michael Bane, who will advise on parallel computing issues.

Required skills. We are seeking a candidate with strong mathematical skills and excellent knowledge of C++. Good communication skills are essential as the candidate will work as a part of a small team. Knowledge of initial value problems is desirable.

Academic benefits. During the course of the project the participant will receive training in numerical methods for solving differential equations, which are essential for modern simulation in science and engineering, and will have an opportunity to work as a part of a small team on a large scale project.

Remuneration. The candidate will receive the remuneration for the period of 8 weeks corresponding to the standard University scale for this post.

How to apply. Applications are invited from all suitably qualified candidates. In addition to the formal application, a copy of the CV with a one paragraph cover letter should be forwarded to Dr Milan Mihajlovic at (milan@cs.man.ac.uk) by 18 April 2019. The shortlisted candidates will be interviewed and the successful applicant will be notified by 29 April 2019.