Publishable Summary

QCOALA is a collaboration between European companies and research organisations funded through FP7. The project has been completed in July 2014 and has the objective of improving the laser welding of highly reflective materials, through the development of a fully integrated dual wavelength manufacturing work cell. The project developed a new fully integrated manufacturing system for automated high yield, laser welding of copper and aluminium (weld penetration depths in the range of 0.1-1.5mm). Welding strategies were developed to suit these types of applications and materials, and were integrated with process monitoring and non-destructive inspection sensors. The integrated QCOALA system was successfully demonstrated on two industrial applications: car battery and solar module electrical interconnections.

The project focused on energy-efficient, environmentally-friendly and agile manufacturing, through feed-back of in-line-monitoring and inspection into the production line, allowing process control and continuous quality improvement and waste reduction. Whereas the concept of the project aimed at smarter and more energy-efficient manufacturing, the applications that were addressed in the project were categorised in the 'green' alternative energy market.

The main technological developments are:

- A dual wavelength laser source (GreenMix) for thin sheet welding: The laser source has been tested on thin copper and aluminium electrical interconnections. The system has already been commercialised.
- A proof-of-concept prototype Weld Monitoring System (WMS) for 532nm and 1µm laser wavelengths: The system performs on-line quality monitoring of laser welds of aluminium and copper. Lack of fusion and deviation in penetration depth were monitored indirectly by monitoring weld pool geometry and radiant power of optical radiation emitted from keyhole during welding.
- Post-weld, in-line digital radiography and eddy current technologies were developed to detect small defects (up to sizes of a few tens of nm) in thin-gauge aluminium and copper interconnections, using modelling and experimental work. Defects that could be detected included internal porosity and cracks and surface defects (eg blow holes and cracks).
- A laser welding processing platform with combined 1µm and 532 nm wavelengths, for the joining of: aluminium to aluminium, copper to copper and aluminium to copper material configurations, at thickness >1mm.
- A laser joining platform with combined 1µm and 532nm wavelengths, for joining of charge collection tapes to contacts of CIGS flexible solar modules, at thickness <30µm.

Impact of the QCOALA technologies spans over 30 events attended and/or presented as well as 4 IPR outputs (2 patents, 1™, 1 Design).

The above results will facilitate the introduction of advanced laser processing into mainstream manufacturing of electrical interconnection products. This has the potential of increasing productivity by 50-100% and process yield by 2-10%.

The integrated QCOALA technologies were successfully demonstrated on both the Flisom solar module and Volkswagen battery module joining applications. These systems demonstrated all the developments within project, including the dual-wavelength laser source, the weld monitoring system and post-weld inspection systems together with their user interfaces. The impact of the demonstrators on production, e.g. throughput, compared with conventional manufacturing, was assessed. A marketing video was produced and can be viewed on the QCOALA website (www.qcoala.eu).

Within the project all the end users have been supplied with innovative technologies and the project has focused on applying the advancements of these technologies to industrial applications that the end users would directly benefit from.

The technologies being developed for thin sheet aluminium and copper welding have the potential of being scaled to larger joint sizes and applied to other applications requiring automation, in-process control and monitoring.