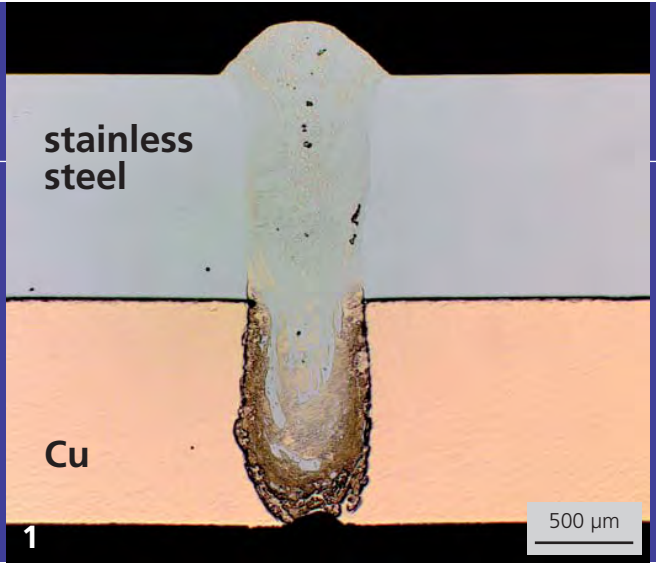
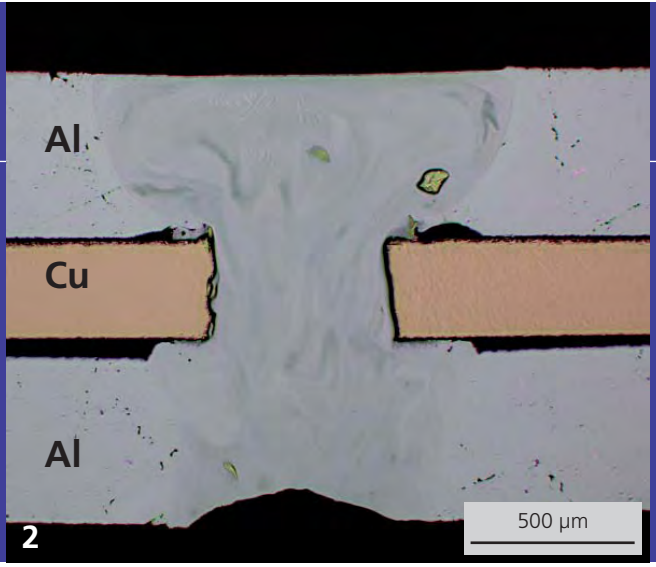




LASER BEAM WELDING OF MIXED MATERIAL JOINTS

THE TASK

It is a general requirement to manufacture components with optimized weight and performance properties. Consequently, the formation of mixed material joints are established as a bonding technology for many applications. The capability to weld combinations of different materials is used to benefit from the specific properties of these materials. Such welded parts include components made from materials matching their specific mechanical loads. This approach offers a better functional integration and a highly optimized overall weight.

Unfortunately, it is often difficult to weld mixed material joints. The individual components typically vary in thermophysical and other material properties. Significantly, differences in melting temperatures, thermal conductivities and thermal coefficients of expansion lead to problems melting both welding partners and also cause melt turbulences. The resulting solidifying melt contains new mixed crystals and alloyed phases with extreme hardness and brittleness such as for example intermetallic phases. These form due to diffusion processes at heat treatment temperatures exceeding the material specific processing temperature range. Thus these processes significantly affect the metallurgical compatibility of a material combination.

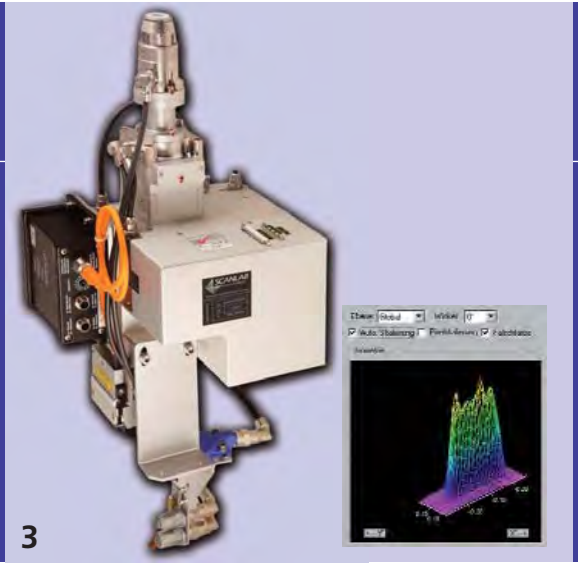
However, overall beam based welding processes are comparatively well suited to cost effectively fabricate mixed material joints. Laser processes are used to very efficiently weld the material combinations Al / steel, HSS / heat treatable steel and cast iron / case hardening steel. Electron beam welding further increases the palette of available mixed material joints.

However, electron beam welding equipment is substantially more expensive and also complicates the process integration into the manufacturing line due the vacuum system requirements. Consequently new flexible and process efficient technologies are sought.

OUR SOLUTION

Engineers at the Fraunhofer IWS used a highly dynamic beam scanning unit to significantly improve the quality of laser welded mixed material joints from Al / Cu, stainless steel / Cu and Al / Mg. A brilliant laser beam is rapidly scanned along and across the welding joint using tilting mirrors. The effort is funded through a collaborative project WELDIMA and focuses on the development of a highly dynamic 2D scanner with scanning frequencies of up to 2.5 kHz (Fig. 3).

During the process the laser beam power is manipulated, which improves the degree of material mixing and also affects melt turbulences. In addition the controlled laser processes affects the melting behavior of both materials. Laser beams of high brilliance are very well focusable. This affords the fabrication of very narrow weld seams with high aspect ratios and extremely shortened melt lifetimes. Consequently the energy deposition into the part is drastically reduced, which limits the formation of brittle intermetallic phases.



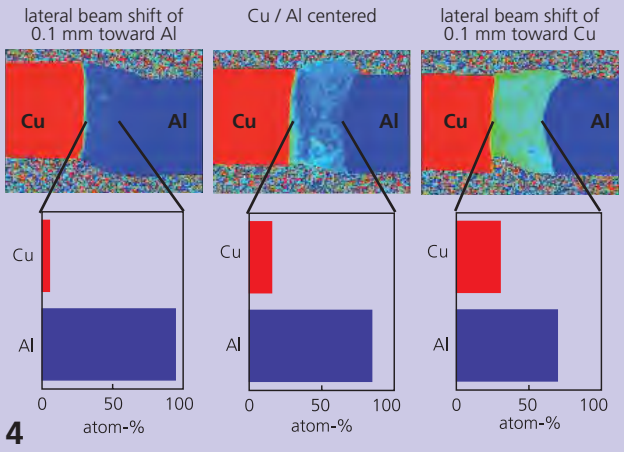
3

RESULTS

Key to the welding process performance is the control of the mixing ratio of both material partners, which is achieved via the lateral beam shifting in the welding joint region at high beam oscillation frequencies. This approach leads to a reproducible and tailored control of the width of the intermetallic phase seam. Fig. 4 shows a resulting laser welded mixed material joint of the system Al / Cu.

The utilization of brilliant lasers in the kW power range makes it possible to achieve phase seam widths of less than 10 µm for Al / Cu depending on the beam shift. For millimeter thick welded mixed material joints the process results in achievable tensile strengths on the order of 70 % of the weaker and non-affected partner. The tensile strength is similar to that of a same-material joint of the weaker partner.

EDX analysis of the chemical element distribution in laser welded Al-Cu mixed material joints



4

The laser power modulation is superimposed over the high frequency 2D beam scanning and shifts the resulting weld properties close to the metal physical limits. So far these regions were not accessible by laser welding processes. The new technology offers further possibilities to cost effectively manufacture mixed material joints from Cu / steel, Cu / austenitic steel, Cu / Al or Ni / curable carbon steel.

The presented results were developed within a BMBF funded project WELDIMA (funding identification 13N 10197).

1 Cross section of a laser beam welded mixed material joint stainless steel / Cu
2 Cross section of a laser beam welded mixed material joint Al / Cu
4 Laser beam weld head WSS intelliscan 20 FC for the highly dynamic beam scanning

CONTACT

Dr. Jens Standfuß
phone +49 351 83391-3212
jens.standfuss@iws.fraunhofer.de