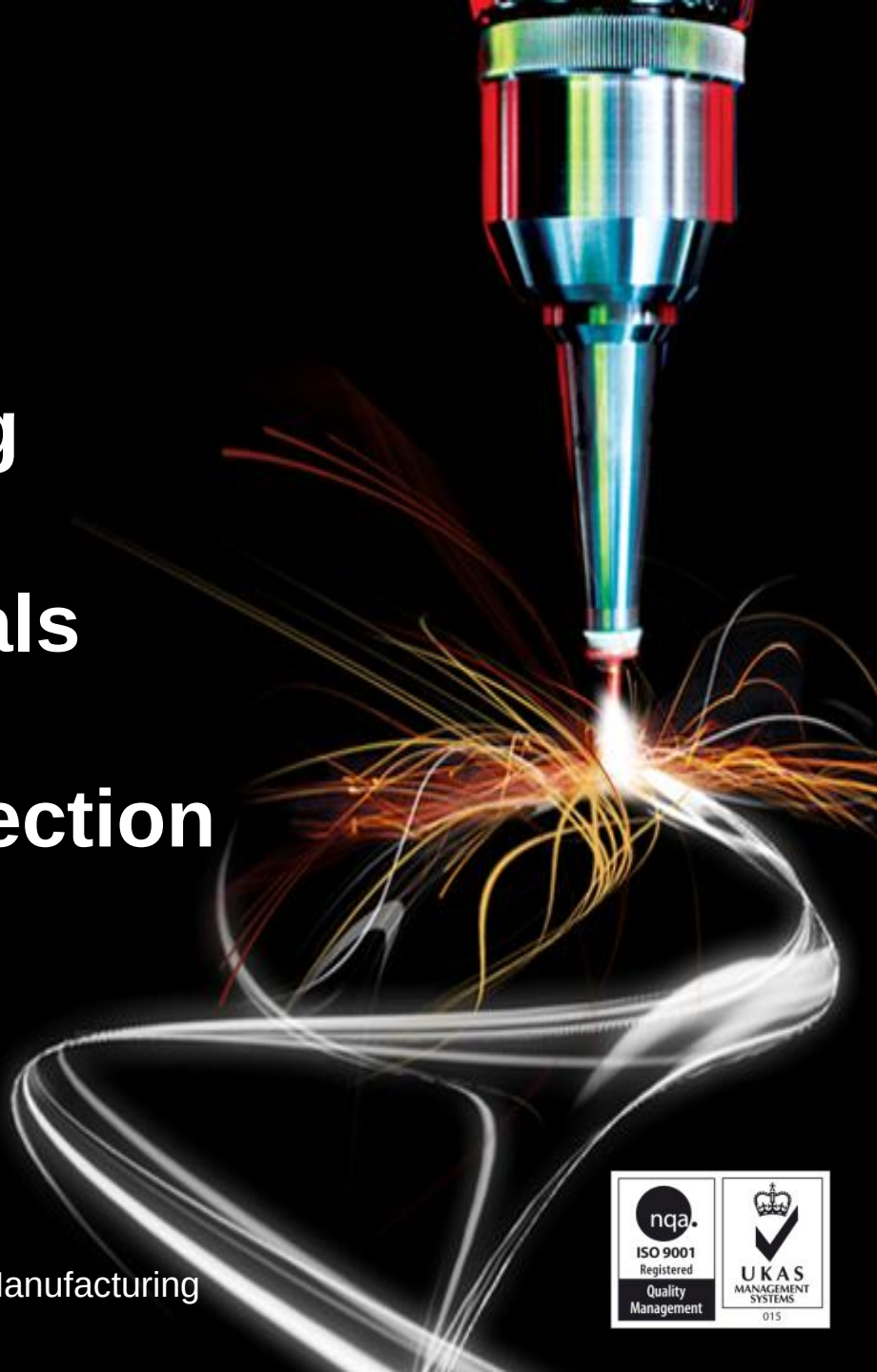
SPI® Lasers

Enabling cutting of Reflective Materials with Back Reflection protection

March 2018



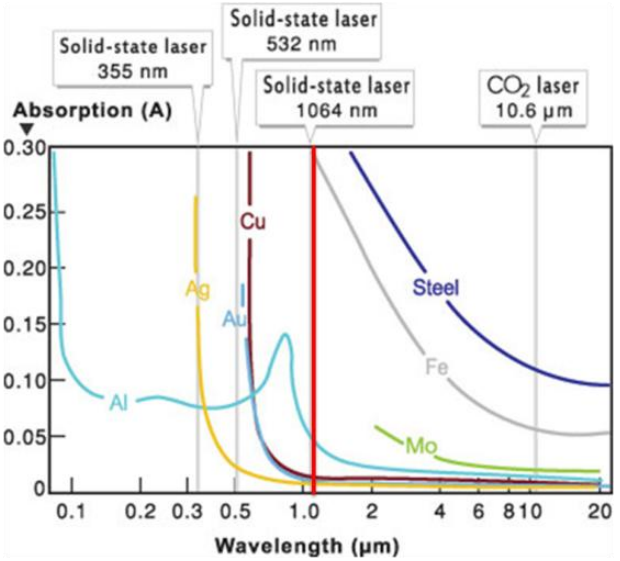
Marking | Cutting | Welding | Micro Machining | Additive Manufacturing

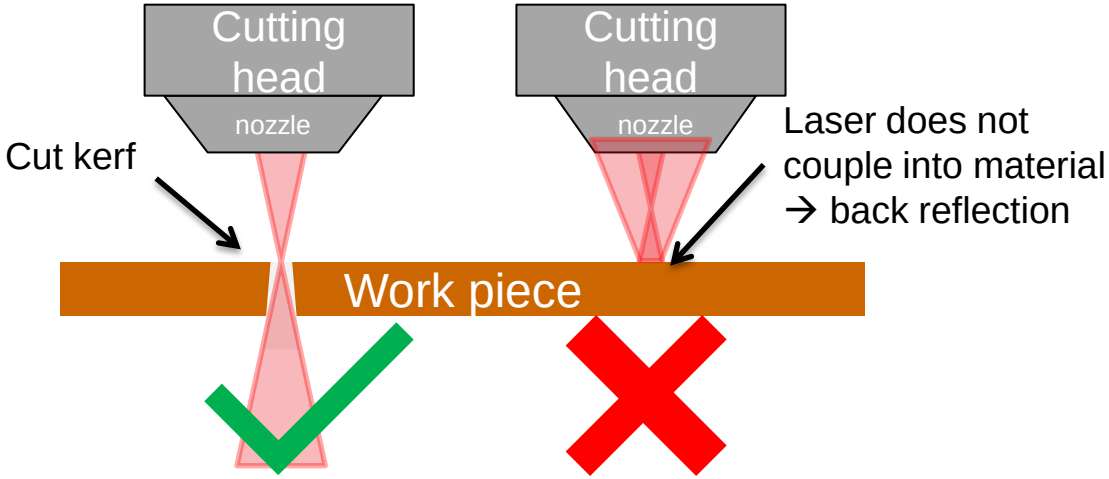
nqa. ISO 9001 Registered Quality Management

UKAS MANAGEMENT SYSTEMS 015

Laser Cutting of Bright Metal

- **Typical high reflectivity materials for cutting with fiber lasers are Copper, Brass and Aluminium**
  - Low absorption characteristic at fiber laser wavelength compared to steels
- **Most of the laser power is reflected rather than absorbed by the work piece**
  - Causes heating of cutting head and fiber termination
  - Radiation can travel back along the delivery fiber and into the laser.





Dealing with Back Reflected Laser Light

- **SPI have a carefully designed system for handling Back Reflected (BR) radiation from the workpiece**
- **The PIPA-Q is designed to be robust against BR radiation**
  - the patented angle capillary is a key part.
- **A large proportion of BR is transmitted back into the laser through the delivery fiber**
  - Devices provide controlled removal of this light within the laser
  - Photodiode monitors provide further protection for the system
- **Specially designed sensors pick up the BR signal**
  - multiple access points for Back Reflected signal
  - & also isolate the BR signal from forward going signal.

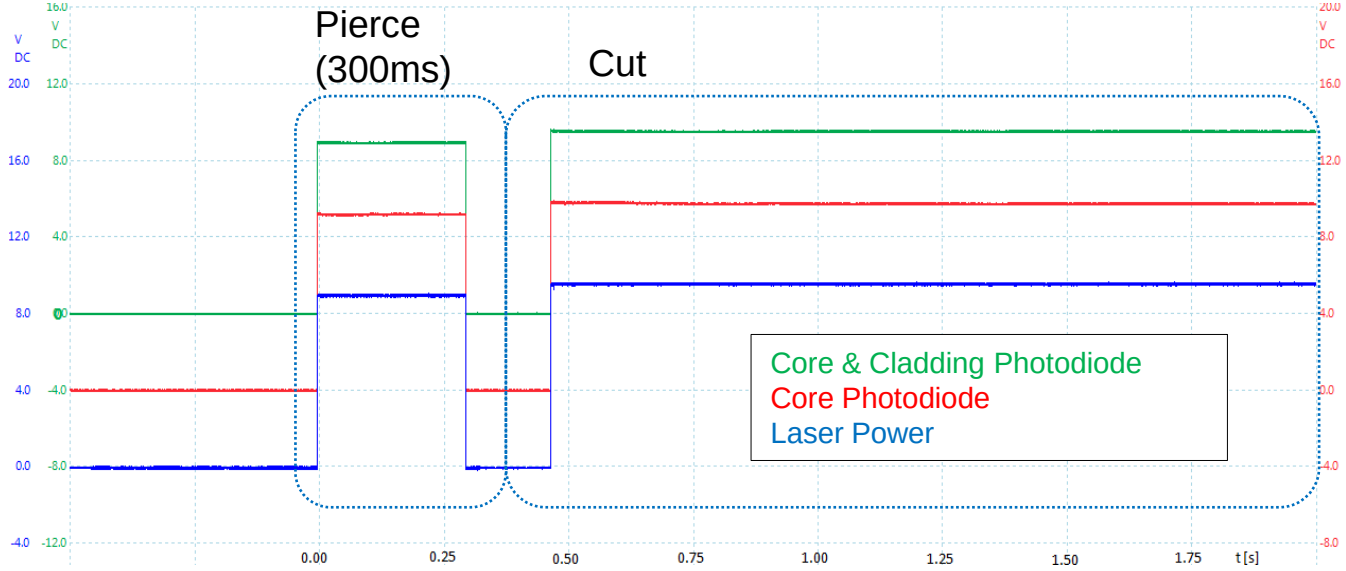
redPOWER QUBE 1.5kW Cutting Trials with Back Reflection

More product information on the stand.

Non-Reflective Cutting – 1.5kW

Cutting non reflective materials shows the following characteristics:

- Both Photodiodes (PDs) follow the demand signal
- Both PDs have the same magnitude
- Shows little BR present.



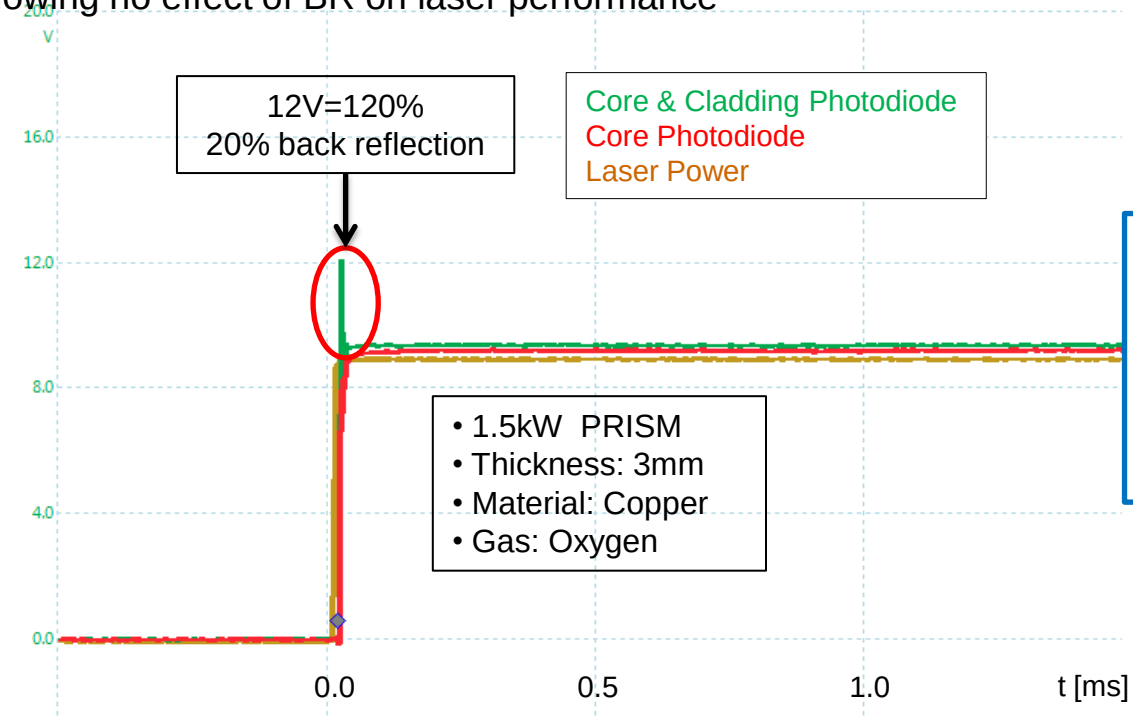
- 1.5kW PRISM
- Thickness: 3mm
- Material: Stainless Steel
- Gas: Nitrogen

Y-Axis:
Voltage calibrated to laser power:
0V = 0% laser power
10V = 100% laser power

Reflective Cutting – Pierce Phase

- **For piercing highly reflective metals there is increased BR during the first few milliseconds:**
  - First peak of back reflection occurs when metal surface is solid
  - Once the laser couples into the material, most of the power is absorbed
  - Absorption increases as metal temperature increases

- **Throughout Laser Power is stable at 100% output:**
  - Showing no effect of BR on laser performance



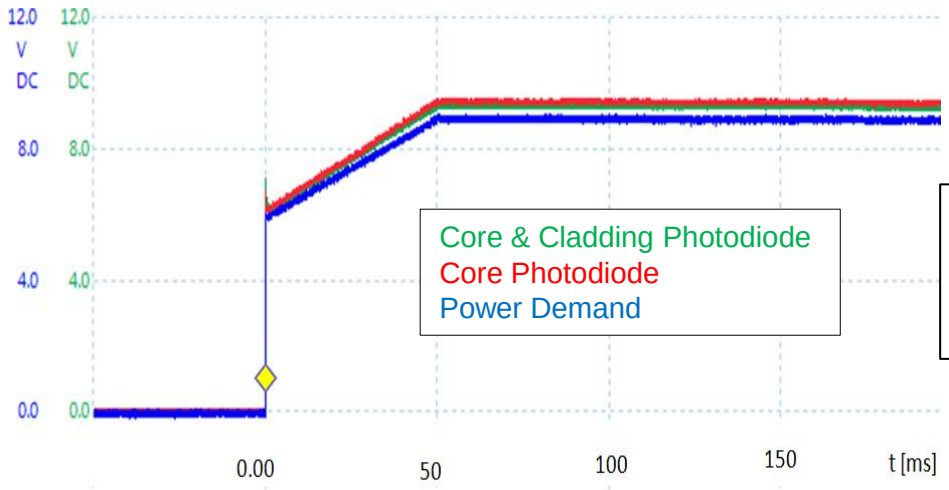
Piercing on highly reflective material:

- Core & Cladding Photodiode is reading 20% (~300W) back reflection

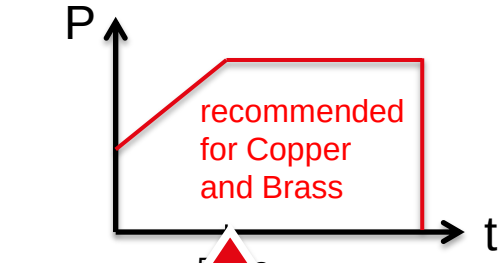
Reflective Cutting – Pierce Phase

- **If necessary SPI have developed a process strategy to avoid the Back Reflection peak, including:**
  - Set focal position on work piece surface
    - Highest intensity encourages fast in-coupling
  - Power ramp to avoid back reflection peak
  - Once coupled in, the laser power can be increased to reduce the overall pierce time.

- **Results below show removal of initial high BR spike.**



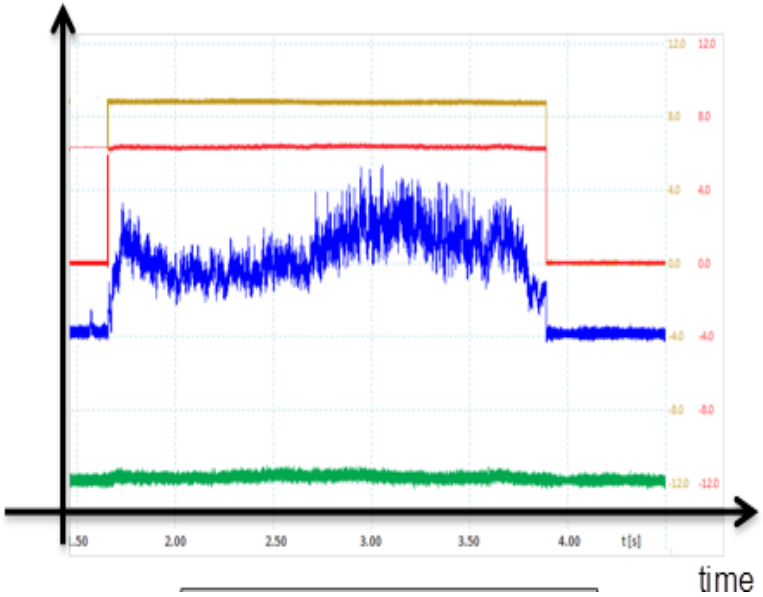
- 1.5kW PRISM
- Thickness: 3mm
- Material: Copper
- Gas: Oxygen



Please visit the SPI stand to discuss details with our Team.

Copper cutting – Nitrogen assist gas.

- **Copper with Nitrogen assist gives one of the highest levels of BR**
- **During cutting phase, the signals show:**
  - A high level of BR on core photodiode
  - That BR is not affecting the laser output power
    - internal power meter trace is steady throughout the cut.
- **The laser design removes the BR before it can reach components where the laser operation would be affected.**



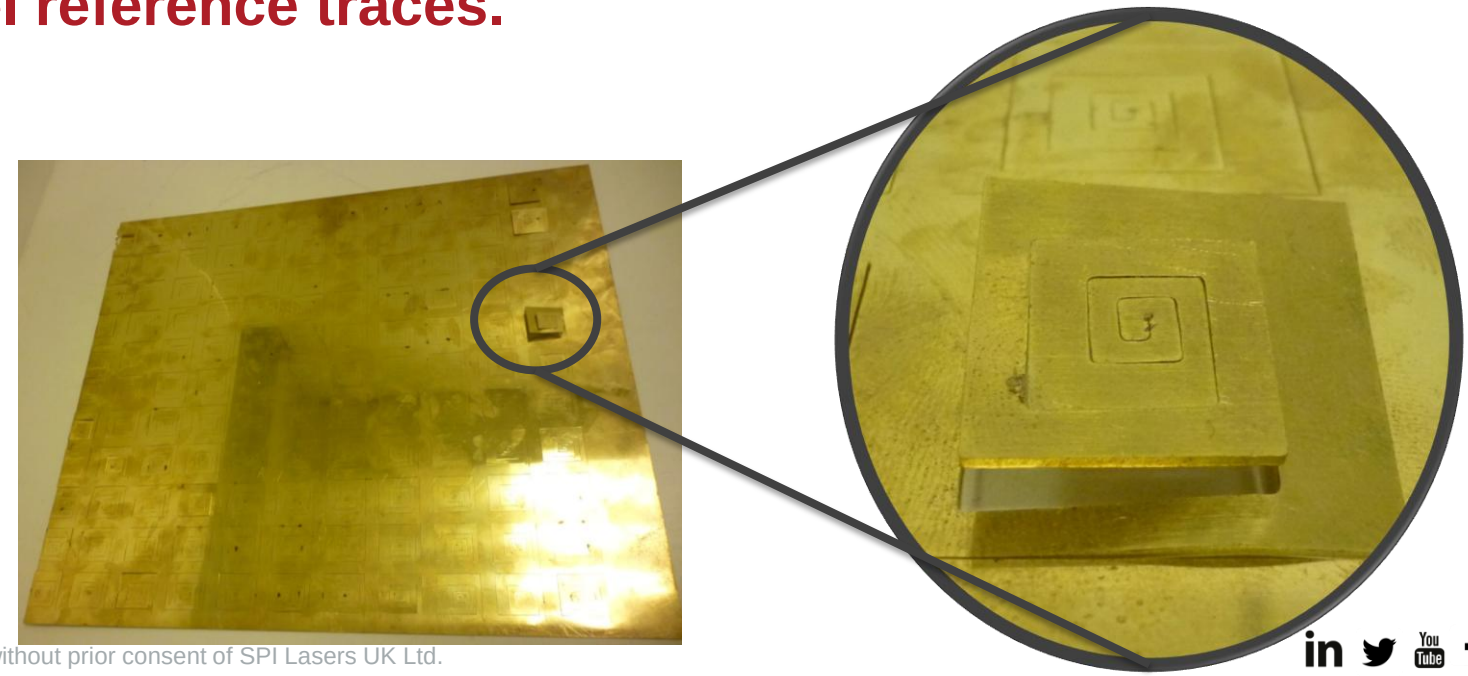
KEY

Power Demand (orange)
Internal Power Meter (red)
Core BR (blue)
Cladding BR (green)

Long Term Validation - 1.5kW

- **More than 240 test parts have been processed for each of Copper and Brass**
  - Cutting speed 14m/min
- **All cuts successfully made with no laser issues**
- **Signals have been monitored during the whole process**
- **Signal traces do not show significant differences in form to Mild Steel reference traces.**

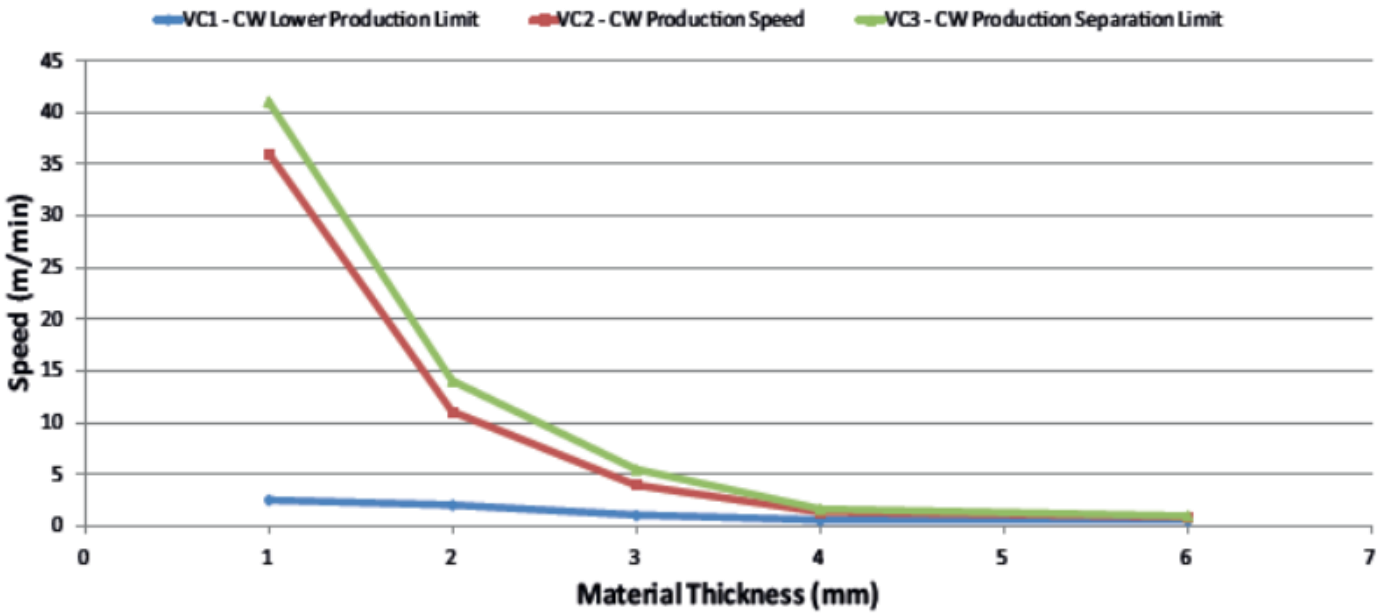
- 1.5kW PRISM
- Thickness: 1mm
- Material: Brass
- Gas: Nitrogen



redPOWER QUBE
2kW Cutting Performance
For Reflective Materials

More product information on the stand.

Aluminium Cutting – 2kW, 50µm fiber

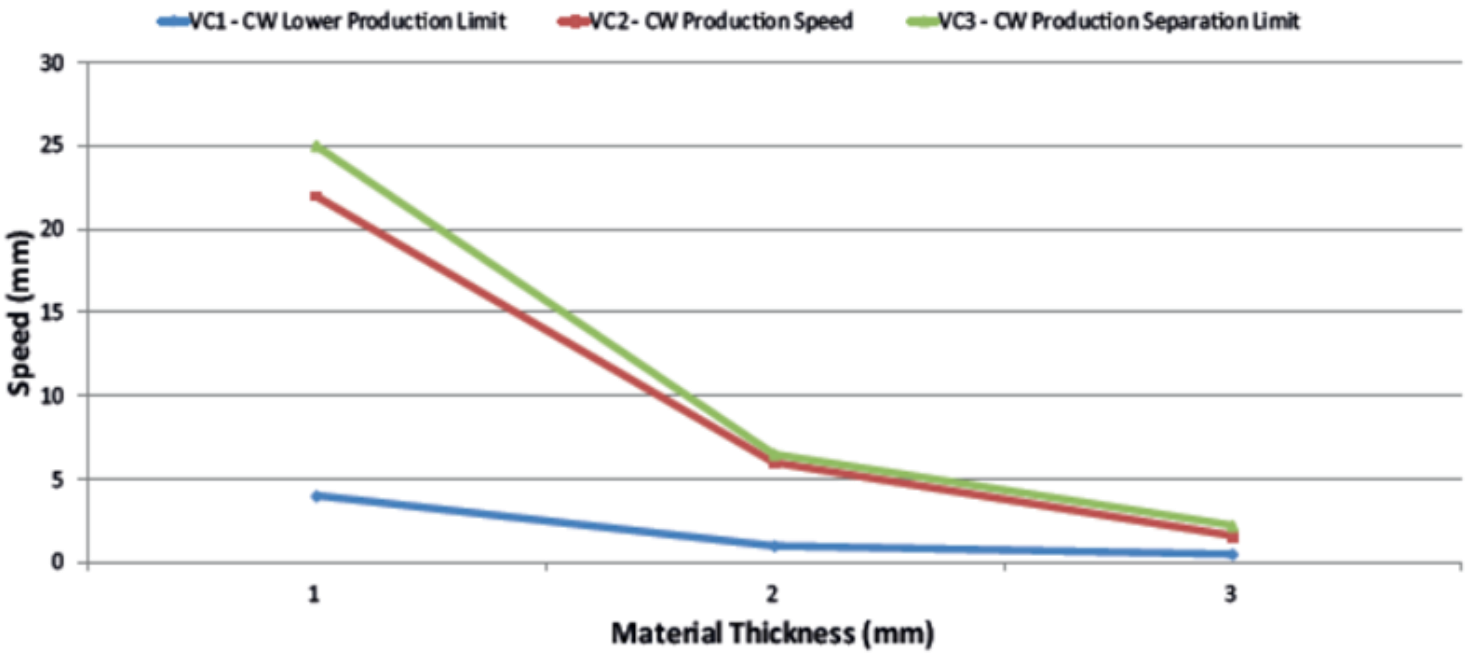


Cutting Speeds on Aluminium

Hints and tips

- Slower speeds will result in higher levels of dross. But this can be easily removed with post processing.
- Dross always remains on aluminium when cutting with nitrogen. The key to the cut quality is how removable and consistent the dross and edge striations are.
- VC2 conditions for Aluminium have Cut Quality Grade 2 – removable dross.

Copper Cutting – 2kW, 50µm fiber

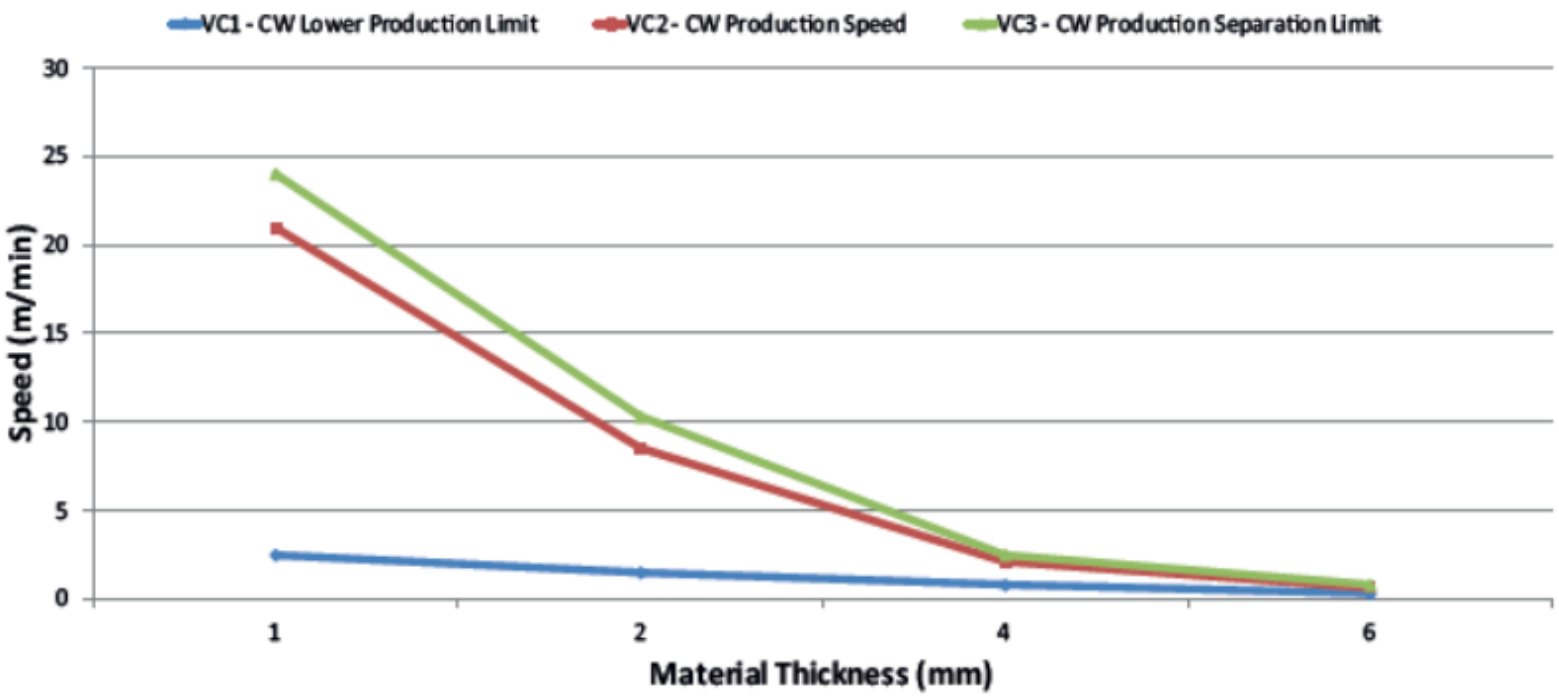


Cutting Speeds on Copper

Hints and tips

- To prevent damaging the laser it is important to use a power ramp while piercing Copper and Brass. The pierce needs to start at 60% of nominal power and then ramp up to 100% over 50ms.
- While piercing the focal position has to be on the surface of the material. When starting the cut move the focus position to the cutting setting as shown in the table.
- Ensure that the oxygen feed-line is fitted with a flash-arrestor.

Brass Cutting – 2kW, 50µm fiber



Cutting Speeds on Brass

Hints and tips

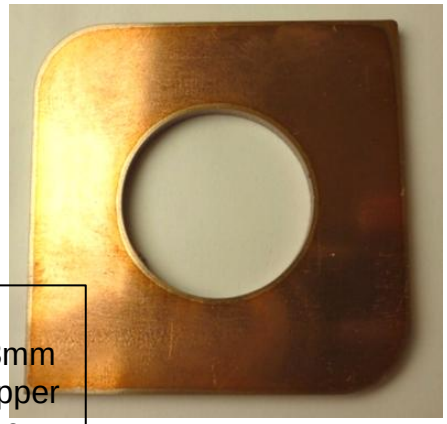
- To prevent damaging the laser it is important to use a power ramp while piercing Copper and Brass. The pierce needs to start at 60% of nominal power and then ramp up to 100% over 50ms.
- The focal position while piercing has to be on the surface of the material. Once the pierce is finished, focal position can be lowered to cutting position.

redPOWER QUBE 6kW Cutting Trials with Back Reflection

More product information on the stand.

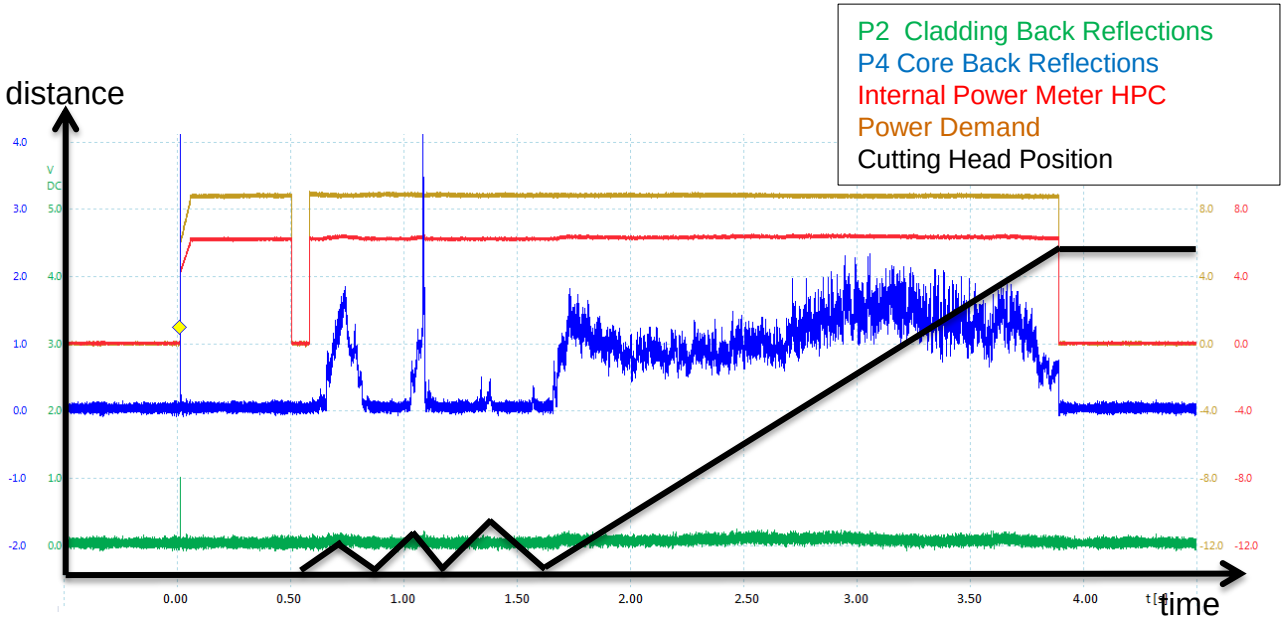
Reflective Cutting: Copper with Nitrogen

- **A short peak in core and cladding BR during Piercing**
- **First single BR peaks while cutting are due to the lead-in strategy**
- **The laser is unaffected by these levels of BR**
  - Laser power output is constant
- **BR during cutting is dependant on feed rate**
  - Full cutting speed was 2.8 m/min.



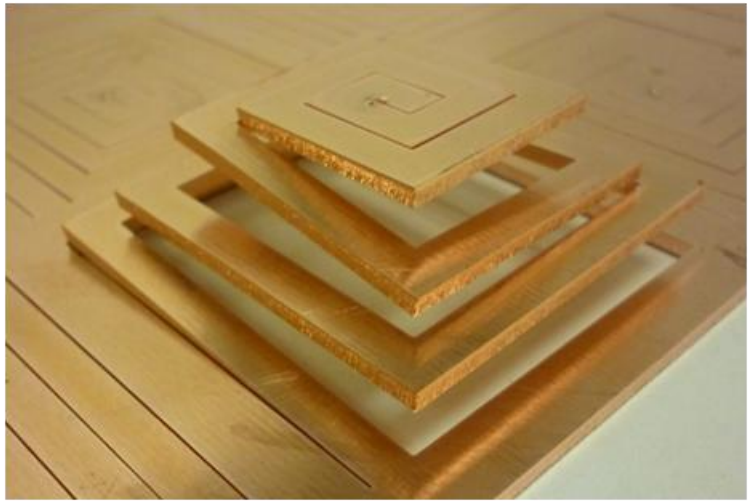
- 6kW QUBE
- Thickness: 3mm
- Material: Copper
- Gas: Nitrogen

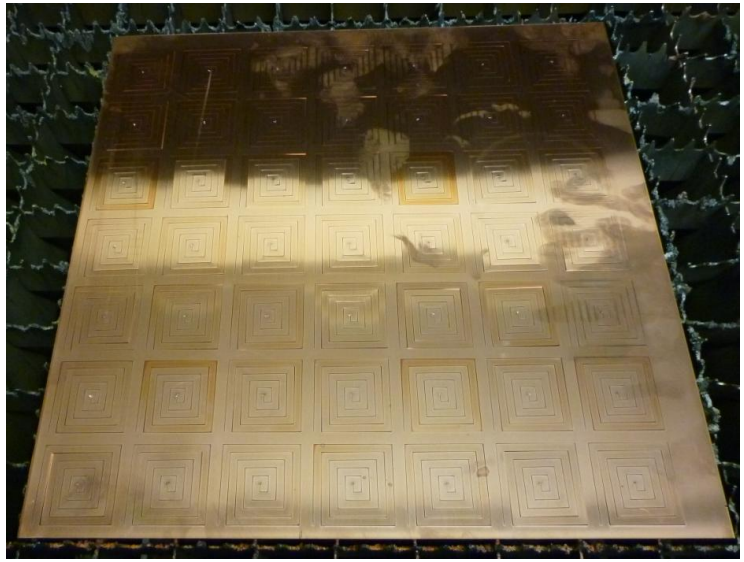
Lead-in Strategy



Long Term Validation - 6kW

- **Long term test using a 6 kW laser**
- **Cutting 2 mm copper:**
  - Nitrogen as an assist gas
  - considered to be one of the most critical processes regarding back reflections
  - Average BR during cutting is about 200W.
- **Cutting speed was 8 m/min**
- **200 µm focal spot diameter**
- **Complete sheet processed with no stoppages.**





Conclusion

- **PRISM & QUBE Fiber lasers can consistently cut highly reflective materials for extended periods with no detrimental effects**
- **Integrated Back Reflection (BR) Protection improves tolerance for reflective material processing**
  - demonstrated for Aluminium, Copper & Brass.
- **SPI lasers are fitted with BR photodiodes which can be used to examine back reflected light**
  - Analysis of BR signals can be used to optimise piercing and cutting processes.
- **The amount of BR depends mainly on the following parameters:**

machine sided	• cutting speed • focal position • nozzle diameter/distance
material sided	• material • surface treatment/condition • assist gas

  - Tests have shown that for piercing the focus position should be on the surface of the work piece.