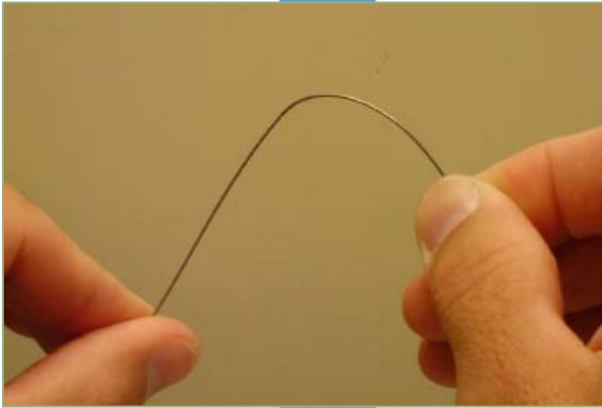


# Welding Nitinol To Ferrous Metals

## INTRODUCTION

The shape memory alloy nitinol is a popular smart material. A wide variety of products uses the Ni-Ti alloy including bend-resistant cell phone antennas, eyeglasses frames, orthodontic arch wires, and self-deploying vascular stents used to prop open blocked arteries.

Nitinol displays two unique properties, shape memory and superelasticity. The shape memory effect allows the metal to fully recover plastic deformation upon heating above a specific temperature. Superelasticity allows the metal to withstand extensive elastic deformations of up to eight percent strain without permanent plastic deformation. A nitinol device can be designed to display either or both of these properties. In addition, nitinol has demonstrated biocompatibility making it an attractive alloy for medical device applications.



However, nitinol also presents some unique manufacturing challenges. Over the years industrial users have developed very successful procedures for laser cutting and machining nitinol. Despite the advances in fabrication techniques, welding nitinol to other ferrous metals such as stainless steels has consistently proven difficult to impossible. This is a particularly attractive metal combination because it allows a manufacturer to use the more expensive nitinol only for the critical elements of a design. Alternative joining methods have been investigated and used for nitinol-to-stainless steel joints such as soldering, brazing, mechanical fastening, and organic adhesives. None of these are straightforward solutions and all have serious shortcomings in terms of strength, application, or impact on the nitinol performance.

## THE CHALLENGE

Successful fusion welding, particularly laser welding, of nitinol to itself has been well established and documented. With proper procedures and high-quality material welding nitinol has become a relatively routine process. However, fusion welding nitinol to other metals, including stainless steels, has proven much more difficult. This is due to the tendency for Ti to form brittle intermetallic phases with most other metals. In the case of ferrous metals the intermetallic phases TiFe and TiFe<sub>2</sub> form. Welding nitinol to stainless steel continues to be a desirable material combination for many applications including medical devices.

Various welding approaches have been considered including resistance welding, friction welding, and using a transition material. Some of the more promising approaches have been solid-state forge welding techniques such as friction and resistance welding. In solid-state welding a bond is formed through the application of heat and pressure, but without large-scale melting of the base metals. The absence of liquid prevents or minimizes the formation of brittle intermetallic phases and can result in a sound weld. These processes are typically limited to particular joint geometries and/or part dimensions. Consequently, despite the apparent feasibility of forge welding its practical application appears to be somewhat limited.



1250 Arthur E. Adams Drive  
Columbus, Ohio 43221

(614) 688-5000  
FAX (614) 688-5001  
[www.ewi.org](http://www.ewi.org)

## **SOLUTION**

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Through its internal research program EWI has developed and patented a more accessible and universally applicable fusion welding process for joining nitinol to stainless steel. One recognized technique for overcoming poor weldability is to modify the weld deposit chemistry through alloy additions made during the welding. This basic approach was investigated as a method of suppressing and/or modifying the brittle Ti-Fe intermetallic phases, primarily Fe<sub>2</sub>Ti, that form in a nitinol-to-stainless steel fusion weld.

EWI discovered that the weld strength could be dramatically improved by making selective transition metal additions to the weld deposit. Successful laser welding of wire-to-wire and tube-to-tube butt joints demonstrate the successful results of this work. Weld tensile strengths were increased from zero to as much as 90ksi. This strength increase was accompanied by a dramatic reduction in the weld metal hardness from 900 down to 450 Vickers hardness. Functionally, the weld strengths are sufficient to allow extensive superelastic bend of the nitinol at the weld. This approach is not limited to just nitinol-to-stainless steel joints. Similar improvements have been demonstrated on joints between carbon steel and titanium.

## **ADDITIONAL BENEFITS**

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- EWI's patented nitinol-to-ferrous metal joining technology is available for license
- EWI provides a licensee with a technology transfer document consisting of know-how that would provide technical information, above and beyond the content of the patents
- Upon request, EWI can provide additional technical assistance to a licensee at EWI member per diem rates to assist in the use of the licensed technology

## **MORE INFORMATION**

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For additional details, please contact:

Shuchi Khurana  
Phone: 614-688-5250; E-mail: [skhurana@ewi.org](mailto:skhurana@ewi.org)