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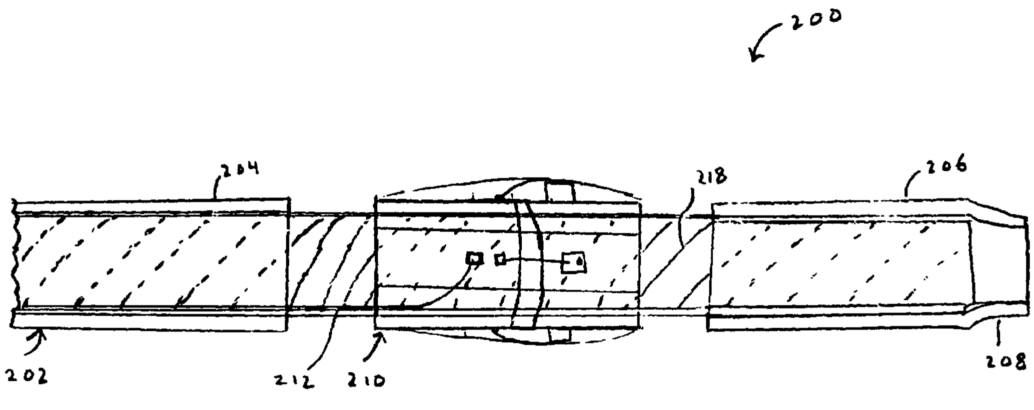

(57) Abstract: A platform for delivering laser light comprising a carrier and one or more apparatuses for generating laser light attached to the carrier. The carrier has a tubular configuration comprising a proximal end and a distal end with openings at the proximal end and the distal end, and a hollow center between the proximal end and distal end. Also, a device for delivering laser light to the inside of a hollow tubular structure or through a small opening to a location distal to the opening comprising the platform. Further, a method of treating coronary artery disease associated with narrowing of the lumen of one or more coronary arteries.

WO 01/13781 A2

LASER DELIVERY SYSTEM

CROSS-REFERENCE TO RELATED APPLICATION

This Application takes priority from United States Patent Application 60/150,735, filed August 25, 1999 and entitled "Laser Catheter and Guidewire," the contents of which are incorporated by reference in its entirety into this disclosure.

BACKGROUND

Coronary artery disease is a major source of morbidity and mortality in the United States and in other developed countries. Coronary artery disease frequently results from narrowing or occlusion of the blood vessels supplying the heart. One method of treating coronary artery disease related to such narrowing or occlusion involves the insertion of a catheter having an inflatable balloon into the blood vessel and inflating the balloon at the area of narrowing to dilate the narrowing and increase blood flow to the heart. This procedure is known as balloon angioplasty.

One disadvantage with balloon angioplasty is that there is a high rate of recurrence of narrowing several months to several years after the procedure. It has been found that the application of laser light to the area of narrowing in conjunction with the use of balloon angioplasty decreases the rate of recurrence. However, it remains difficult to deliver laser light into the small and tortuous cardiac vasculature where the narrowing frequently occurs.

Further, laser light has been found to be beneficial in a number of applications involving the human body. However, administration of laser light into the body through small openings remain difficult.

Therefore, there remains a need for a device which can deliver laser light into the cardiac vasculature. Further, there is a need for a method for reducing the rate of recurrence of narrowing of the cardiac vasculature after a coronary angioplasty procedure. Additionally, there remains a need for a device which can deliver laser light through small openings, such as through small openings in a human body.

SUMMARY

According to one embodiment of the present invention, there is provided a platform for delivering laser light. The platform comprises a carrier and one or more apparatuses for generating laser light attached to the carrier. The carrier has a tubular configuration comprising a proximal end and a distal end with openings at the proximal end and the distal end, and a hollow center between the proximal end and distal end. Preferably, the carrier comprises an outer circumference having one or more than one flat areas and each of the one or more apparatuses for generating laser light are mounted on the one or more than one flat area. In a preferred embodiment, the carrier comprises eight flat areas.

In one embodiment, the carrier comprises a non-conductive material, such as a metal coated with a non-conductive coating, a ceramic or polyimide. In another embodiment, the carrier has an inner circumference defining the hollow center. Preferably, the inner circumference is cylindrical.

In a preferred embodiment, the platform further comprises a stress breaker extending between the proximal end and the distal end of the carrier. The stress breaker can comprise a stainless steel wire or a flexible polymer tube. Preferably, the platform comprises a non-conductive sheath surrounding the stress breaker.

In another preferred embodiment, the platform comprises four apparatuses for generating laser light. Each of the apparatuses for generating laser light preferably produces laser light at a wavelength of between about 600 nm and about 900 nm, and more preferably produces laser light at a wavelength of about 780 nm. In a particularly preferred embodiment, each of the apparatuses for generating laser light is a vertical cavity surface emitting laser.

In one embodiment, the platform comprises a proximal metalization band and a distal metalization band extending circumferentially around the carrier and separated by an unbanded region. Each of the one or more apparatuses for generating laser light is attached to the carrier upon the distal metalization band and is electrically connected to the proximal metalization band by a connecting wire which arcs over the unbanded region. When the one or more apparatuses for generating laser light are a plurality of apparatuses for generating laser light, each of the plurality of apparatuses for generating laser light is connected in parallel with the other apparatuses for generating laser light.

In one embodiment, the platform comprises a sealant potted on the platform. In a preferred embodiment, the carrier has a length between the proximal end and the distal end of less than about 1.5 mm. Further, the carrier preferably has a maximum outer diameter of less than about 1 mm.

In another preferred embodiment of the present invention, there is provided a device for delivering laser light to the inside of a hollow tubular structure or through a small opening to a location distal to the opening. The device comprises a platform according to the present invention. The device further comprises a flexible elongate structure, and the platform is mounted on the flexible elongate structure. In a preferred embodiment, the device further comprises a guidewire, and the platform is mounted on the guidewire. In a particularly preferred embodiment, the guidewire has a proximal portion and a distal portion with a tip and the platform is mounted on the distal portion of the guidewire near the tip.

In one embodiment, the guidewire has a diameter of between about 0.3 mm and about 0.4 mm. In another embodiment, the guidewire is covered by a non-conductive sheath.

In a particularly preferred embodiment, the device further comprises a power source, such as a disposable battery. In another particularly preferred embodiment, the device further comprises electrically conductive leads connected proximally to a power source and electronic control circuit and distally to the carrier, and one or more sheaths surrounding the guidewire and leads.

In a preferred embodiment, the device further comprises a catheter connected to the platform. In a particularly preferred embodiment, the platform comprises a stress breaker extending between the proximal end and the distal end of the platform, the catheter has a proximal portion and a distal portion and the proximal portion and the distal portion of the catheter are connected to the stress breaker.

In a particularly preferred embodiment, the catheter comprises an inflation balloon. Preferably the catheter has a diameter of less than about 1 mm, not including the inflation balloon. The platform can be inside the inflation balloon.

In another preferred embodiment, the device comprises electrically conductive leads connected proximally to a power source and electronic control circuit and distally to the carrier, and one or more sheaths surrounding the catheter and leads.

In a preferred embodiment, there is provided a kit for delivering laser light to the inside of a hollow tubular structure having a lumen with a small internal diameter or through a small opening to a location distal to the opening. The kit comprises a device according to the present invention. The kit can further comprise a power source and electronic control circuit.

In one embodiment of the present invention, there is provided a method of making a device for delivering laser light to the inside of a hollow tubular structure, or through a small body opening to a location distal to the opening. The method comprises providing a platform for delivering laser light according to the present invention. The method can further comprise advancing a guidewire covered with a non-conductive sheath through the platform and attaching the guidewire to the platform.

In another preferred embodiment, the method further comprises providing a catheter having a proximal portion and a distal portion and connecting the proximal portion and the distal portion to the platform. In a particularly preferred embodiment, the platform comprises a stress breaker and the proximal portion of the catheter and the distal portion of the catheter are connected to the stress breaker.

In another embodiment of the present invention, there is provided a method of delivering laser light to the inside of a hollow tubular structure or through a small body opening to a location distal to the opening. The method comprises providing a device according to the present invention. Preferably, the method further comprises placing the device through an opening in the body and advancing the device until the platform is adjacent to the area to receive the laser light, and then actuating the device, thereby administering a specific dosage of laser light to the area. Additionally, the method can comprise placing a stent adjacent the area which received the laser light. The method can also comprise inflating a balloon on the device at or near the area which receives the laser light.

In a particularly preferred embodiment, the present invention is a method of treating coronary artery disease associated with narrowing of the lumen of one or more coronary arteries. The method comprises placing a guide catheter into the ostium of the coronary artery to be treated, inserting a device for delivering laser light according to the present invention into the guide catheter and advancing the device into the coronary artery and across the narrowing to the location to receive laser treatment. Then, an over-the-wire rapid exchange balloon angioplasty catheter is back-loaded over the device and balloon angioplasty is performed. The device is actuated to deliver laser treatment to the location before, during or after performing balloon angioplasty. The method can also comprise implanting a stent.

FIGURES

These and other features, aspects and advantages of the present invention will become better understood from the following description, appended claims, and accompanying figures where:

Figure 1 a side perspective view of a platform, according to the present invention;

Figure 2 is a partial, side perspective view of one embodiment of a device for delivering laser light to the inside of a hollow tubular structure or through a small opening to a location distal to the opening, according to the present invention;

Figure 3 is an enlarged view of the distal portion of the device shown in Figure 2;

Figure 4 is a partial, side perspective view of another embodiment of a device for delivering laser light to the inside of a hollow tubular structure or through a small opening to a location distal to the opening, according to the present invention; and

Figure 5 is an enlarged view of the distal portion of the device shown in Figure 4.

DESCRIPTION

In one embodiment of the present invention, there is provided a platform for delivering laser light. In another preferred embodiment, there is provided a device for delivering laser light to the inside of a hollow tubular structure such as the inside of a coronary artery, or through a small opening to a location distal to the opening.

In a particularly preferred embodiment, the device comprises the platform mounted on a guidewire. In another particularly preferred embodiment, the device comprises the platform mounted on a catheter, such as a coronary balloon angioplasty catheter. Both of the devices comprising a guidewire and a catheter allow the delivery of laser light to the inside of a hollow tubular structure having a lumen with a small internal diameter. Further, both of these devices can be introduced into the lumen of a highly curved, hollow tubular structure having a small internal diameter to place the platform portion of the device deep within the lumen of the structure. Additionally, all of these devices can be introduced through a small opening to a location distal to the opening.

In another embodiment, there is provided a method of delivering laser light to the inside of a hollow tubular structure having a lumen with a small internal diameter or through a small opening to a location distal to the opening. In a preferred embodiment, there is provided a method for delivering laser light to the inside of a human vascular structure, such as a coronary artery. The methods include providing a device according to the present invention, advancing the device into the lumen of the hollow tubular structure or through a small opening to a location distal to the opening such that the platform is adjacent the area which will receive the laser light, and actuating the device to deliver laser light to the area. The method is suitable for use in conjunction with coronary angioplasty, as well as after coronary artery bypass or other vascular procedures.

Referring now to Figure 1, there is shown a side perspective view of the platform 10, according to the present invention. The platform 10 is designed to be incorporated into a guidewire, catheter or other suitable flexible elongate structure for delivering the platform into a hollow tubular structure having a small internal diameter or through a small opening to a location distal to the opening.

The platform 10 comprises a carrier 12. The carrier 12 comprises a generally non-conductive material, such as a metal coated with a non-conductive coating such as polyimide or such as a ceramic. In a preferred embodiment, the carrier 12 comprises polyimide (available from HV Technologies, Inc., Trenton, GA US).

The carrier 12 preferably has a tubular configuration, comprising a hollow center 14 with openings at the proximal end 16 and the distal end 18, and with an inner circumference 20 defining the hollow center 14. The center 14 is preferably cylindrical, though it can be another shape, as will be understood by those with skill in the art with reference to this disclosure. When the platform 10 surrounds a guidewire, catheter or stress breaker, the center 14 should be a shape and size to allow a guidewire, catheter or stress breaker to pass through the center 14 in order to join the platform 10 to the guidewire, catheter or stress breaker.

The carrier 12 further comprises an outer circumference 22 having one or more than one flat area 24. The outer circumference 22 is configured to provide a minimum overall profile to permit placement of the platform 10 in a hollow tubular structure having a lumen with a small internal diameter or through a small opening to a location distal to the opening.

In one preferred embodiment, the platform 10 also comprises a stress breaker (shown in Figure 4 and Figure 5) for the carrier 12, passing between the proximal end 16 and the distal end 18 and extending beyond the proximal end 16 and the distal end 18. The stress breaker allows the carrier 12 to be joined to sections of a catheter proximal and distal to the platform 10. When present, the stress breaker lines the inner circumference 20 of the carrier 12 and joins the platform 10 to the proximal and distal sections of a catheter. The stress breaker allows lateral flexibility of the catheter joined to the platform 10 without transmitting excess stress to the platform 10, thereby preventing the components of the platform 10 from separating from the catheter during use.

In a preferred embodiment, the inner circumference 20 of the carrier 12 is round and the stress breaker comprises stainless steel wire having a thickness of 0.05 mm and having an inner diameter of 0.4 mm and an outer diameter of 0.5 mm. When the stress breaker comprises metal, the stress breaker further comprises a non-conductive sheath surrounding the stress breaker. In a preferred embodiment, the sheath is a 0.025 mm thick, polymer shrink tubing (Advanced Polymers, Inc., Salem, NH US). In another preferred embodiment, the stress breaker comprises a flexible polymer tube such as polyimide.

The platform 10 additionally comprises one or more apparatuses for generating laser light 26 or one or more sensors (not shown), each of which is mounted to a flat area 24 on the carrier 12. In a preferred embodiment, the platform 10 comprises at least two apparatuses for generating laser light 26. In a particularly preferred embodiment, the platform 10 comprises four apparatuses for generating laser light 26, equally spaced about the outer circumference 22 of the platform 10. In this latter embodiment, particularly, laser light can be provided to essentially all of the inner circumference of the wall of a lumen simultaneously without having to rotate the platform 10 along its proximal to distal axis. When the platform 10 comprises sensors instead of apparatuses for generating laser light 26, the sensors can be used to gather physiological information on blood flow, heart wall motion, temperature or other physiological parameters, as will be understood by those with skill in the art with reference to this disclosure.

Each of the apparatuses for generating laser light 26 preferably emits between about 6 and about 10 mW of power for between about 10 minutes and about 20 minutes and produces laser light at a wavelength of between about 600 nm and about 900 nm. In a particularly preferred embodiment, each of the apparatuses for generating laser light 26 produces laser light at a wavelength of 780 nm when treating coronary arteries after an angioplasty procedure.

In one embodiment, each of the apparatuses for generating laser light 26 is a super high intensity or super luminescent red LED. In a preferred embodiment, each of the apparatuses for generating laser light 26 is a vertical cavity surface emitting laser, a VCSEL, emitting a wavelength of between about 630 nm and about 850 nm (Samsung Electronics, Suwan City, South Korea). Preferably, each of the apparatuses for generating laser light 26 emits the same wavelength, when the device includes a plurality of apparatuses for generating laser light 26. However, the apparatuses for generating laser light 26 can emit two or more wavelengths when the device includes a plurality of apparatuses for generating laser light 26.

In another preferred embodiment, the carrier 12 has a circular inner circumference 20 and an eight-sided outer circumference 22, as shown in Figure 1. This configuration is particularly preferred when the platform 10 comprises four apparatuses for generating laser light 26, where each of the four apparatuses for generating laser light 26 can be attached to the carrier 12 on one of the alternating eight flat areas 24. However, other configurations are also suitable, as will be understood by those with skill in the art with reference to this disclosure.

The platform 10 preferably comprises two metalization bands, a proximal metalization band 28 and a distal metalization band 30. The proximal metalization band 28 and the distal metalization band 30 extend circumferentially around the carrier 12 and are separated by an unbanded region 32. Preferably, each of the one or more apparatuses for generating laser light 26 is attached to the carrier 12 upon the distal metalization band 30 by low temperature solder or, preferably, by conductive silver epoxy.

The platform 10 further comprises a bond pad 34 of conductive material, such as gold, that is bonded to the proximal metalization band 28, such as by a conductive silver epoxy. Each of the one or more apparatuses for generating laser light 26 is electrically connected to the proximal metalization band 28 by a connecting wire 36 bonded to the outer surface of the apparatus for generating laser light 26 which arcs over the unbanded region 32 and is attached to the proximal metalization band 28 at the bond pad 34. The connecting wire 36 is preferably a gold wire which is soldered to the bond pad 34 and the top of each of the one or more apparatuses for generating laser light 26.

When the platform 10 comprises more than one apparatus for generating laser light 26, each of the apparatuses for generating laser light 26 is connected to the proximal metalization band 28, thereby connecting each of the apparatuses for generating laser light 26 in parallel with the other apparatuses for generating laser light 26.

In a preferred embodiment, the platform 10 comprises a sealant which is potted on the platform 10 to protect the platform 10 components and render a smooth longitudinal profile to the device. In a preferred embodiment, the sealant is a clear, biocompatible epoxy such as Epo-Tek® 301 (Epoxy Technologies, Inc., Billerica, MA, US).

In another preferred embodiment, the carrier 12 has a proximal to distal length that does not interfere significantly with the lateral flexibility of the flexible elongate structure on which the platform 10 is mounted. In a particularly preferred embodiment, the carrier 12 has a proximal to distal length of between about 1 mm and about 1.5 mm. For example, in a particularly preferred embodiment, the carrier 12 has a proximal to distal length of about 1 mm.

Further preferably, the carrier 12 has a maximum outer diameter, not including the apparatuses for generating laser light 26 or sensors, that is between about 0.9 mm and about 1.3 mm. Preferably, the maximum outer diameter of the carrier 12 is less than about 1 mm. This small outer diameter allows the platform 10 to deliver laser light to the inside of hollow tubular structures having lumen diameters the size of the coronary arteries after an angioplasty procedure.

Additionally, the platform 10 is rigid in its proximal to distal axis to prevent excessive stress on the components of the platform 10, so that the components of the platform 10 do not separate from the rest of the device during use.

Referring now to Figure 2 and Figure 3, there are shown a partial, side perspective view of one embodiment of the device 100 for delivering laser light to the inside of a hollow tubular structure, according to the present invention and an enlarged view of the distal portion of the device shown in Figure 2. As can be seen, the device 100 comprises a guidewire 102 having a proximal portion 104 and a distal portion 106 with a tip 108. In a preferred embodiment, the guidewire 102 has a diameter of between about 0.3 mm and about 0.4 mm.

The device 100 further comprises a platform 110 for delivering laser light, according to the present invention. The platform 110 is mounted on the distal portion 106 of the guidewire 102. In a preferred embodiment, the platform 110 is mounted on the distal portion 106 adjacent the tip 108. However, the platform 110 can be mounted a considerable distance away from the tip 108 depending on the configuration of the structure to receive the laser light generated by the platform 110, as will be understood by those with skill in the art with reference to this disclosure.

The device 100 further comprises a non-conductive sheath 112 covering the guidewire 102 to prevent grounding of the device 100 when the device 100 is powered. The sheath 112 preferably covers the entire guidewire 102, except the tip 108. In a preferred embodiment, the sheath is a polymer shrink tubing (Advanced Polymers, Inc.).

Further, the device 100 comprises electrically conductive leads 114 connected proximally to a power source (not shown) and electronic control circuit (not shown) and distally to the proximal metalization band 118 and to the distal metalization band 120 of the platform 110. The positive lead of the leads 114 is connected to the proximal metalization band 118 and the negative lead of the leads 114 is connected to the distal metalization band 120.

The leads 114 travel laterally along the length of the guidewire 102, either parallel to the guidewire 102 or wrapped spirally around the guidewire 102. In either case, a sheath, 116 fixes the electrically conductive leads 114 to the guidewire 102 by covering the guidewire 102 and leads 114 from the platform 110 to the proximal end of the guidewire 102, with or without covering the platform 110, or by covering the guidewire 102 and leads 114 intermittently, as shown, from the platform to the proximal end of the guidewire 102. The electrically conductive leads 114 are preferably made of 0.05 mm diameter polytetrafluorethylene (PTFE) coated copper wire (Phoenix Wire, Inc., South Hero, VT US), though other suitable materials can be used, as will be understood by those with skill in the art with reference to this disclosure.

Preferably, the power source and electronic control circuit are disposable and presterilized, such as a disposable battery, so that the device can be used in situations where standard power sources are not available, though a standard power source can also be used. When the power source is disposable, it is preferably a battery having at least about 6 volts to provide at least 50 mA of power for at least a continuous ten minute discharge of laser light and more preferably for at least a continuous 20 minutes discharge of laser light. In a preferred embodiment, the battery is a lithium ion polymer (Valence Technology, Inc., Henderson, NV US). In another preferred embodiment, the battery is a zinc chloride disposable battery (PowerBurst, Waltham, MA US). Both of these batteries are able to supply at least 50 mA for at least 10 minutes.

Referring now to Figure 4 and Figure 5, there are shown, respectively, a partial, side perspective view of another embodiment of the device 200 for delivering laser light to the inside of a hollow tubular structure, according to the present invention, and an enlarged view of the distal portion of the device 200 shown in Figure 4. As can be seen, the device 200 comprises a catheter 202 having a proximal portion 204 and a distal portion 206 with a tip 208. In a preferred embodiment, the catheter 202 has a maximum outer diameter of about 1 mm, not including an inflated balloon, when one is present.

The device 200 further comprises a platform 210 for delivering laser light, according to the present invention. The platform 210 is mounted on the distal portion 206 of the catheter 202. In a preferred embodiment, the platform 210 is mounted on the distal portion

206 adjacent the tip 208 and distal to an inflation balloon 220, when one is present. However, the platform 210 can be mounted a considerable distance away from the tip 208, or can be mounted proximally to the inflation balloon or inside the inflation balloon, depending on the configuration of the structure to receive the laser light generated by the platform, as will be understood by those with skill in the art with reference to this disclosure.

Further, the device 200 comprises electrically conductive leads 212 connected proximally to a power source (not shown) and electronic control circuit (not shown) and distally to the proximal metalization band 214 and to the distal metalization band 216 of the platform 210. The positive lead of the leads 212 is connected to the proximal metalization band 214 and the negative lead of the leads 212 is connected to the distal metalization band 216.

The leads 212 travel laterally along the length of the catheter 202, either parallel to the catheter 202 or wrapped spirally around the catheter 202. In either case, a sheath, not shown, fixes the electrically conductive leads 212 to the catheter 202 by covering the entire catheter 202 and leads 212 from the platform 210 to the proximal end of the catheter 202, with or without covering the platform 210, or by covering the catheter 202 and leads 212 intermittently from the platform 210 to the proximal end of the catheter 202. The electrically conductive leads 212 are preferably made of 0.05 mm diameter polytetrafluorethylene (PTFE) coated copper wire (Phoenix Wire, Inc.), though other suitable materials can be used, as will be understood by those with skill in the art with reference to this disclosure.

In another preferred embodiment, a stress breaker 218 connects the platform 210 to the remainder of the catheter body and allows lateral flexibility of the catheter without transmitting excess stress to the platform 210. As can be seen, the stress breaker 218 passes through the platform 210 and extends into the catheter body proximal and distal to the platform 210 for between about 2 mm and about 10 mm. In a preferred embodiment, the stress breaker 218 passes through the platform 210 and extends into the catheter body proximal and distal to the platform 210 for about 5 mm. In a particularly preferred embodiment, the stress breaker 218 has an outer diameter of 0.51 mm, while the inner diameter of the platform 210 is 0.53 mm.

In another preferred embodiment, the present invention comprises a kit having a presterilized catheter embodiment of the device according to the present invention. In still another preferred embodiment, the present invention comprises a kit having a presterilized catheter embodiment of the device according to the present invention, and a guidewire packaged as a single unit. Additionally, the present invention comprises a kit having a presterilized guidewire embodiment of the device according to the present invention. Each of these kits can further comprise a power source and electronic control circuit.

The design of the device of the present invention allows direct application of laser light without attenuation by fiberoptic delivery devices. Further, the small maximum diameter of the device of the present invention allows it to be placed in blood vessels for extended periods without compromising blood flow. This, in turn, allows the device of the present invention to be used to apply laser light to multiple locations without completely withdrawing the device.

In one embodiment of the present invention, there is provided a method of making a device for delivering laser light to the inside of a hollow tubular structure such as the inside of a coronary artery, or through a small body opening to a location distal to the opening. The method comprises providing a platform for delivering laser light according to the present invention. Next, a guidewire covered with a non-conductive sheath is advanced through the platform until the platform is at the desired distance from the distal end of the guidewire, and attached by an adhesive or other suitable method, as will be understood by those with skill in the art with reference to this disclosure. Then, the electrically conductive leads are attached by epoxy or by solder. In a preferred embodiment, another non-conductive sheath is then applied to fix the electrically conductive leads to the guidewire by covering the entire guidewire and leads from the platform to the proximal end of the guidewire, with or without covering the platform, or by covering the guidewire and leads intermittently from the platform to the proximal end of the guidewire. Finally, the leads are connected to the power source and electronic control circuit.

In another embodiment of the present invention, there is provided a method of making a device for delivering laser light to the inside of a hollow tubular structure such as the inside of a coronary artery, or through a small body opening to a location distal to the opening. The method comprises providing a platform for delivering laser light according to the present invention. Next, the platform is introduced over the stress breaker and bonded, preferably by using an adhesive such as Epo-Tek® 301. Then, the stress breaker is attached by a suitable method such as an adhesive to the proximal and distal ends of a catheter which are encased by a non-conductive sheath. Next, electrically conductive leads are attached by epoxy or by solder. In a preferred embodiment, another non-conductive sheath is then applied to the combined catheter and platform enclosing all components of the device from a location on the catheter that is proximal to platform to a location that is distal to the platform, or covering the catheter and leads intermittently from the platform to the proximal end of the catheter. Finally, the leads are connected to the power source and electronic control circuit.

According to another embodiment of the present invention, there is provided a method of using the device for delivering laser light to the inside of a hollow tubular structure, such as the inside of a coronary artery, or through a small body opening to a location distal to the opening, according to the present invention. The method comprises providing a device according to the present invention. The device is then placed through an opening in the body and advanced until the platform is adjacent the area to receive the laser light. Next, the device is actuated and a specific dosage of laser light is administered for a specific time. The total amount of laser light delivered is determined according to the application, as will be understood by those with skill in the art with reference to this disclosure. For example, a device according to the present invention would comprise four VSCELs powered at 8 mW and each generating laser light at 780 nm for between about 5 minutes and about 10 minutes. Alternately, a device according to the present invention would comprise four super luminescent LEDs powered at 322 lx and each generating laser light in the red spectrum for between about 5 minutes and about 10 minutes, The device can be used in conjunction with coronary angioplasty with or without stent placement, or with another intravascular or non-vascular procedure.

According to another embodiment of the present invention, there is provided a method of treating coronary artery disease associated with narrowing of the lumen of one or more coronary arteries. In one embodiment, the method comprises placing a guide catheter into the ostium of the coronary artery to be treated. Next, a device for delivering laser light according to the present invention having a catheter is inserted into the guide catheter and advanced into the coronary artery and across the narrowing to the location to receive laser treatment.

Then, an over-the-wire rapid exchange balloon angioplasty catheter is back loaded and fed over the device but not advanced fully to the location of the narrowing. The balloon angioplasty catheter is then advanced to the location of the narrowing and balloon angioplasty is performed. In a preferred embodiment, a stent is then implanted. The balloon angioplasty catheter is then withdrawn. The device is actuated to deliver laser treatment to the location before, during or after balloon angioplasty, or while the stent is being implanted, or during more than one of these periods, or can deliver laser treatment during any other time while the platform is in the proper position, as will be understood by those with skill in the art with reference to this disclosure.

Although the present invention has been discussed in considerable detail with reference to certain preferred embodiments, other embodiments are possible. For example, in another embodiment of the present invention, the present invention comprises a device and method for delivering laser treatment through a small opening to a location distal to the opening. In one such embodiment, the platform of the present invention can be mounted on a catheter having drainage holes suitable to function as an indwelling wound drain. Further, in this embodiment, the device can be programmed to provide a preselected dose of laser light at preselected intervals inside the body cavity. Therefore, the scope of the appended claims should not be limited to the description of preferred embodiments contained in this disclosure.

I CLAIM:

1. A platform for delivering laser light, comprising a carrier and one or more apparatuses for generating laser light attached to the carrier;

where the carrier has a tubular configuration comprising a proximal end and a distal end with openings at the proximal end and the distal end, and a hollow center between the proximal end and distal end.

2. The platform for delivering laser light according to claim 1, where the carrier further comprises an outer circumference having one or more than one flat areas; and

where each of the one or more apparatuses for generating laser light are mounted on the one or more than one flat areas.

3. The platform for delivering laser light according to claim 1, where the carrier comprises a non-conductive material.

4. The platform for delivering laser light according to claim 3, where the material is selected from the group consisting of a metal coated with a non-conductive coating, and a ceramic.

5. The platform for delivering laser light according to claim 3, where the material is polyimide.

6. The platform for delivering laser light according to claim 1, where the carrier has an inner circumference defining the hollow center, and where the inner circumference is cylindrical.

7. The platform for delivering laser light according to claim 1, further comprising a stress breaker extending between the proximal end and the distal end of the carrier.

8. The platform for delivering laser light according to claim 7, where the stress breaker comprises a stainless steel wire.

9. The platform for delivering laser light according to claim 7, where the stress breaker comprises a flexible polymer tube.

10. The platform for delivering laser light according to claim 7, further comprising a non-conductive sheath surrounding the stress breaker.

11. The platform for delivering laser light according to claim 1, where the one or more apparatuses for generating laser light are four apparatuses for generating laser light.

12. The platform for delivering laser light according to claim 1, where each of the apparatuses for generating laser light produces laser light at a wavelength of between about

600 nm and about 900 nm.

13. The platform for delivering laser light according to claim 1, where each of the apparatuses for generating laser light produces laser light at a wavelength of about 780 nm.

14. The platform for delivering laser light according to claim 1, where each of the apparatuses for generating laser light is a vertical cavity surface emitting laser.

15. The platform for delivering laser light according to claim 2, where the outer circumference has eight flat sides.

16. The platform for delivering laser light according to claim 1, further comprising a proximal metalization band and a distal metalization band extending circumferentially around the carrier and separated by an unbanded region.

17. The platform for delivering laser light according to claim 16, where each of the one or more apparatuses for generating laser light is attached to the carrier upon the distal metalization band; and

where each of the one or more apparatuses for generating laser light is electrically connected to the proximal metalization band by a connecting wire which arcs over the unbanded region.

18. The platform for delivering laser light according to claim 1, where the one or more apparatuses for generating laser light are a plurality of apparatuses for generating laser light; and

where each of the plurality of apparatuses for generating laser light are connected in parallel with the other apparatuses for generating laser light.

19. The platform for delivering laser light according to claim 1, further comprising a sealant potted on the platform.

20. The platform for delivering laser light according to claim 1, where the carrier has a length between the proximal end and the distal end of less than about 1.5 mm.

21. The platform for delivering laser light according to claim 1, where the carrier has a maximum outer diameter of less than about 1 mm.

22. A device for delivering laser light to the inside of a hollow tubular structure or through a small opening to a location distal to the opening, the device comprising the platform according to claim 1.

23. The device according to claim 22, further comprising a flexible elongate structure, where the platform is mounted on the flexible elongate structure.

24. The device according to claim 22, further comprising a guidewire, where the platform is mounted on the guidewire.

25. The device according to claim 24, where the guidewire has a proximal portion and a distal portion;

where the distal portion has a tip; and

where the platform is mounted on the distal portion of the guidewire near the tip.

26. The device according to claim 24, where the guidewire has diameter of between about 0.3 mm and about 0.4 mm.

27. The device according to claim 24, further comprising a non-conductive sheath covering the guidewire.

28. The device according to claim 24, further comprising a power source.

29. The device according to claim 28, where the power source is a disposable battery.

30. The device according to claim 24, further comprising electrically conductive leads connected proximally to a power source and electronic control circuit and distally to the carrier.

31. The device according to claim 30, further comprising one or more sheaths surrounding the guidewire and leads.

32. The device according to claim 22, further comprising a catheter connected to the platform.

33. The device according to claim 32, where the platform comprises a stress breaker extending between the proximal end and the distal end of the platform;

where the catheter has a proximal portion and a distal portion; and

where the proximal portion and the distal portion of the catheter are connected to the stress breaker.

34. The device according to claim 32, where the catheter comprises an inflation balloon.

35. The device according to claim 34, where the catheter has a diameter of less than about 1 mm, not including the inflation balloon.

36. The device according to claim 34, where the platform is inside the inflation balloon.

37. The device according to claim 32, further comprising electrically conductive

leads connected proximally to a power source and electronic control circuit and distally to the carrier, and one or more sheaths surrounding the catheter and leads.

38. A kit for delivering laser light to the inside of a hollow tubular structure having a lumen with a small internal diameter or through a small opening to a location distal to the opening, the kit comprising a device according to claim 22.

39. The kit according to claim 38, further comprising a power source and electronic control circuit.

40. A kit for delivering laser light to the inside of a hollow tubular structure having a lumen with a small internal diameter or through a small opening to a location distal to the opening, the kit comprising a device according to claim 24.

41. A kit for delivering laser light to the inside of a hollow tubular structure having a lumen with a small internal diameter or through a small opening to a location distal to the opening, the kit comprising a device according to claim 32.

42. A method of making a device for delivering laser light to the inside of a hollow tubular structure, or through a small body opening to a location distal to the opening, the method comprising providing a platform for delivering laser light according to claim 1.

43. The method according to claim 42, further comprising advancing a guidewire covered with a non-conductive sheath through the platform and attaching the guidewire to the platform.

44. The method according to claim 42, further comprising providing a catheter having a proximal portion and a distal portion; and connecting the proximal portion and the distal portion to the platform.

45. The method according to claim 44, where the platform comprises a stress breaker and where the proximal portion of the catheter and the distal portion of the catheter are connected to the stress breaker

46. A method of delivering laser light to the inside of a hollow tubular structure or through a small body opening to a location distal to the opening, the method comprising providing a device according to claim 22.

47. The method according to claim 46, further comprising, after providing the device:

a) placing the device through an opening in the body and advancing the device until the platform is adjacent the area to receive the laser light;

b) actuating the device, thereby administering a specific dosage of laser light to the area.

48. A method of delivering laser light to the inside of a hollow tubular structure or through a small body opening to a location distal to the opening, the method comprising providing a device according to claim 24.

49. The method according to claim 48, further comprising, after providing the device:

a) placing the device through an opening in the body and advancing the device until the platform is adjacent the area to receive the laser light;

b) actuating the device, thereby administering a specific dosage of laser light to the area.

50. The method according to claim 49, further comprising placing a stent adjacent the area which received the laser light.

51. A method of delivering laser light to the inside of a hollow tubular structure or through a small body opening to a location distal to the opening, the method comprising providing a device according to claim 32.

52. The method according to claim 51, further comprising, after providing the device:

a) placing the device through an opening in the body and advancing the device until the platform is adjacent the area to receive the laser light;

b) actuating the device, thereby administering a specific dosage of laser light to the area.

53. The method according to claim 52, further comprising placing a stent adjacent the area which received the laser light.

54. The method according to claim 52, where the catheter has an inflation balloon, the method further comprising inflating the balloon.

55. A method of treating coronary artery disease associated with narrowing of the lumen of one or more coronary arteries, the method comprising:

a) placing a guide catheter into the ostium of the coronary artery to be treated;

b) inserting a device for delivering laser light according to claim 24 into the guide catheter;

c) advancing the device into the coronary artery and across the narrowing to the location to receive laser treatment;

d) back loading an over-the-wire rapid exchange balloon angioplasty catheter over the device; and

e) performing balloon angioplasty;

where the device is actuated to deliver laser treatment to the location before, during or after performing balloon angioplasty.

56. The method according to claim 55, further comprising implanting a stent.

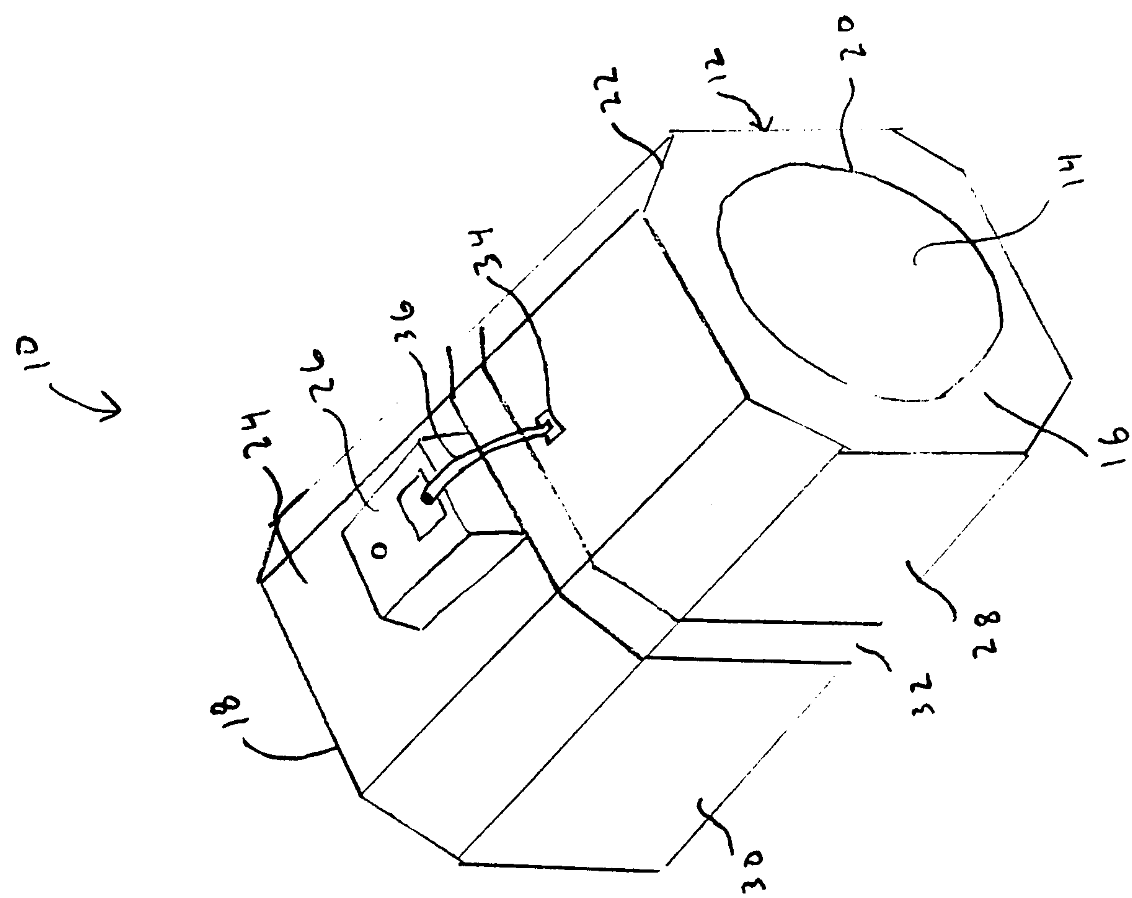

FIGURE 1

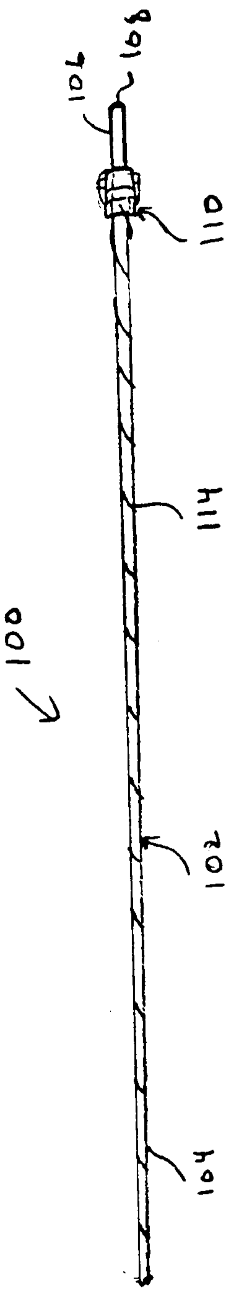

FIGURE 2

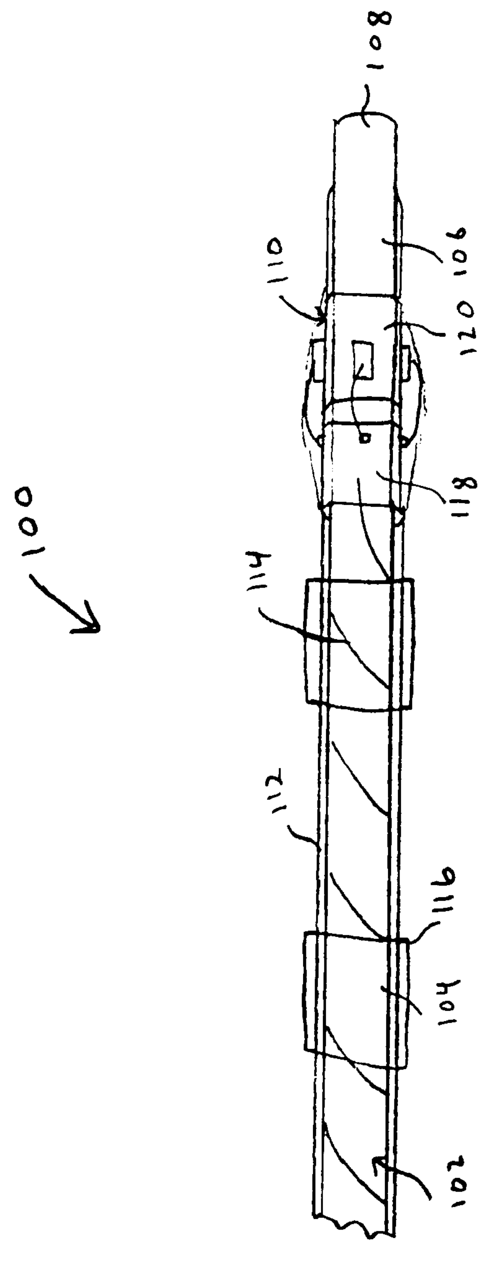

FIGURE 3

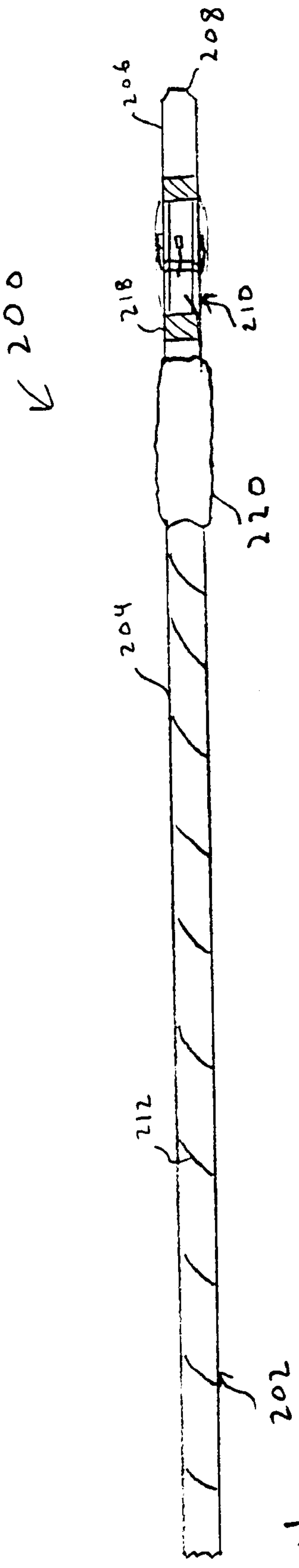

FIGURE 4

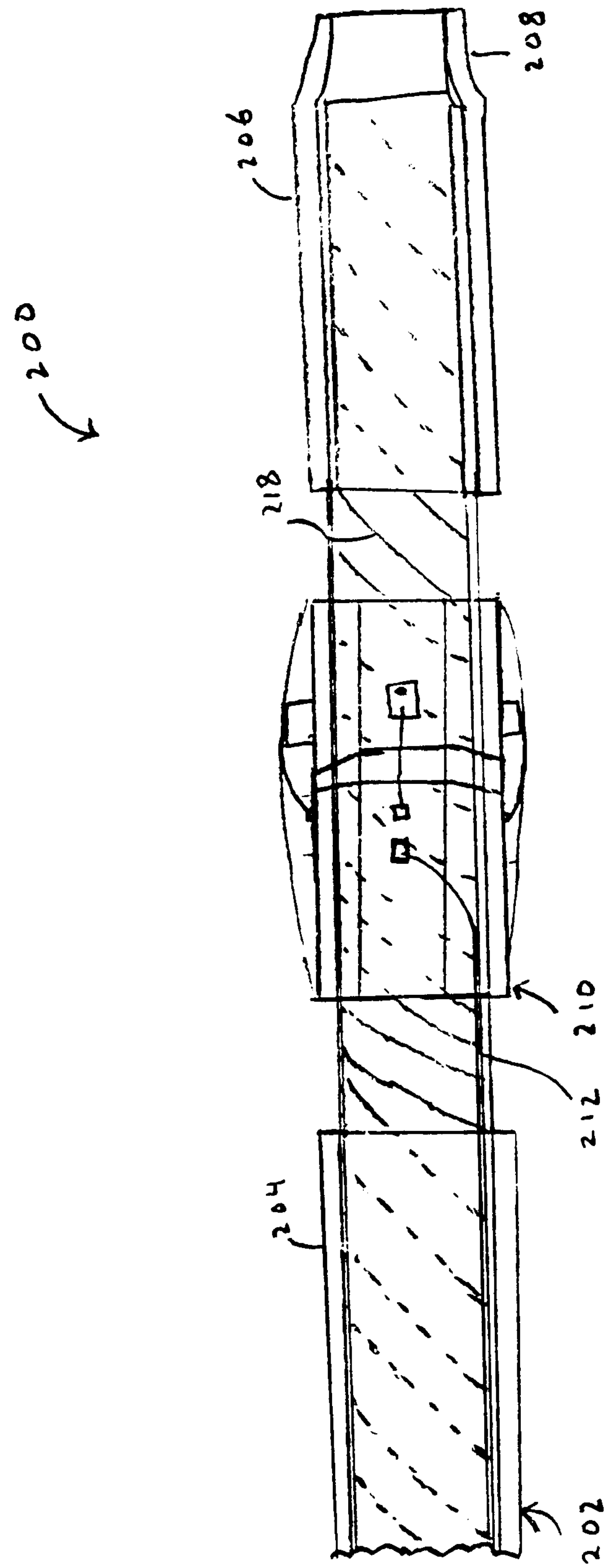

FIGURE 5