IMPROVEMENTS TO THE ALADDIN SYNCHROTRON LIGHT SOURCE*

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Abstract

Aladdin is an IR to soft x-ray synchrotron light source operated by the University of Wisconsin at Madison. As part of the ongoing program of upgrades and improvements, several changes have recently been made to the ring. It had previously been determined that physical apertures (BPMs) at the QF quadrupoles were limiting beam lifetime when the ring was operated in its low emittance configuration. Increasing the size of these apertures has resulted in a significant increase in lifetime. Also as part of the aperture opening process, a number of ring components were redesigned and replaced, lowering the ring impedance. This has led to an increase in the threshold beam current for microwave instability. An insertion device for EUV lithography has been incorporated into one of the Aladdin short straight sections, and an elliptically polarizing undulator will be installed in another short straight section for a new VLS-PGM beamline. An innovative infrared beamline is under construction, which will extract 320 (H) × 25 (V) mrad^2 from a bending magnet by as 12 beamlets, which are combined in an IR microscope. Another modification to Aladdin was the design and installation of discrete trim coils on the quadrupole pole-tips to facilitate using the quads as steering correctors. Details of these improvements are presented.

INTRODUCTION

Aladdin is an 800 MeV/1 GeV electron storage ring operated by the Synchrotron Radiation Center (SRC) of the University of Wisconsin at Madison as a synchrotron light source. Photons from the infrared through the vacuum ultraviolet and soft x-rays are available to Users. We have continued to make improvements to Aladdin and upgrade its capabilities.

APERTURE OPENING

Theoretical and numerical studies were performed on the different processes by which electrons can be lost from the storage ring. It was found that the lifetime of the 800 MeV low emittance (LF15) beam in Aladdin was limited by the horizontal apertures of eight horizontal beam-position monitors (BPMs) located at QF quadrupoles [1]. This was confirmed by experiments in which the lifetime was measured as the horizontal beam position was varied at the BPM locations. The limiting monitors were located at positions around the storage ring where the horizontal dispersion was maximum, leading to beam loss on the monitors.

These limiting apertures were increased by replacing the existing 2-electrode BPMs, whose pick-up electrodes are in the horizontal plane, with 4-electrode BPMs whose electrodes are positioned 45° above and below the horizontal plane.

Lifetime Improvement

Following the reconditioning of the storage ring and establishing new skew quadrupole coupling corrections to restore the *x-y* coupling to its previous value, the lifetime increased approximately 20%. This is a factor of two below the improvement predicted by our Touschek scattering model. This gain in lifetime can be "traded" for a smaller vertical emittance and beam size, which would lead do a direct improvement in the operation of our newer, slitless beam lines. Alternatively, a lower-emittance lattice with smaller horizontal beam sizes can be utilized, giving an increase in the ring's brilliance.

Instability Thresholds

The new BPMs installed as part of the aperture opening program were designed to have low broadband impedance. In addition, when the BPMs were replaced several bellows around the ring were replaced with lower impedance versions. The resulting decrease in ring impedance has raised the threshold for microwave instability from ~165 mA to ~215 mA, distributed in 15 bunches. This has made the beam more stable for Users.

NEW INSERTION DEVICES

The four long straight sections of the roughly square shaped Aladdin ring have been occupied by insertions devices (IDs), some approaching 4 m in length, for many years. However, there is an approximately 1 m drift space available for a short ID in the spaces between each pair of the three 30° dipole magnets making up the corners of Aladdin. We have begun to expand the capabilities of Aladdin by placing IDs in these "short straight sections".

EUV Lithography

During the past year the first of the short straight section insertion devices was installed in Aladdin. This device sources a new Extreme Ultraviolet (EUV) beamline used for nano-lithography [2]. The insertion device required installation of a newly designed vacuum chamber for the undulator, as well as a new chamber for the downstream dipole. As predicted by the vertical aperture ("scraper") measurements made prior to design and construction of the undulator and related vacuum

*Work supported by the U.S. National Science Foundation under Award No. DMR-0537588.

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chambers, no degradation in Aladdin performance resulted.

Plane Grating Monochromator Beamline

A new Variable Line Spacing Plane Grating Monochromator (VLS-PGM) beamline, whose source is an elliptically polarizing APPLE-II undulator (see Fig. 1), is under procurement. This will also make use of a short straight section, and will be the first variable polarization insertion device installed in Aladdin. The beamline will cover the energy range from 10 to 250 eV with more than 2×10^{11} photons/sec and a resolving power of 5000. This flux will be delivered in a spot size of less than 200 μm × 40 μm (horizontal × vertical). We expect it to become one of our premier beamlines for condensed matter research.

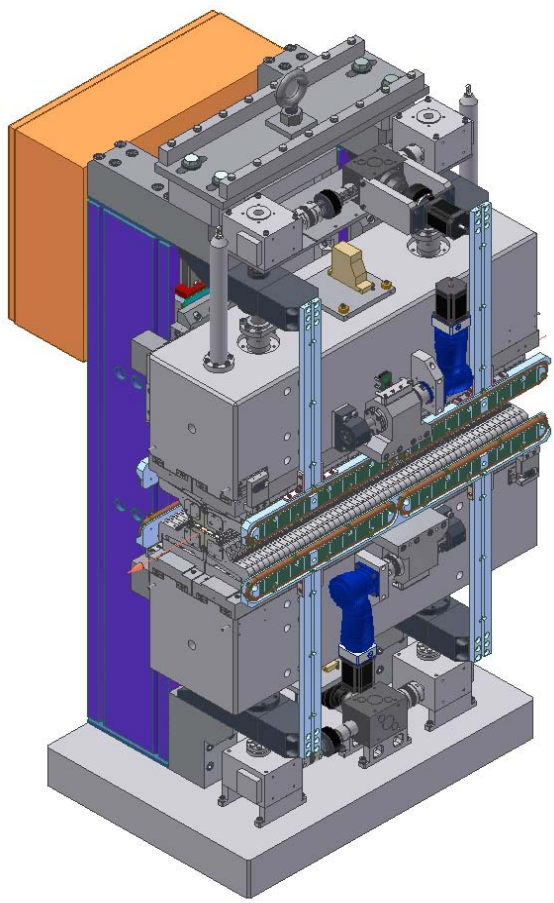

Figure 1: Assembly view of the APPLE-II undulator to be installed in an Aladdin short straight section, for a new PGM beamline. (Courtesy of ADC [3].)

A LARGE ACCEPTANCE INFRARED BEAMLINE

A novel new mid-infrared beamline, funded by an NSF grant to an SRC User, is under procurement at SRC. It will extract 320 × 25 (horizontal × vertical) mrad^2 of light from a bending magnet and will be coupled to a commercial IR microscope and homogeneously illuminate its multi-element detector [4]. The beamline will consist of twelve 25 × 30 mrad^2 beams that will be demagnified and independently steered to fill a 40 × 40 μm^2 sample area at the sample plane of a commercial infrared microscope, a Bruker Hyperion Microscope with a 128 × 128 pixel focal plane array detector. It will be equipped with a 20× Schwarzschild condenser and a 74× Schwarzschild objective achieving effective geometric pixel sizes of 0.54 × 0.54 μm^2 at the detector. This pixel size is equal to λ/2.8 for even the shortest wavelengths of 2 μm, providing adequate information for point spread function (PSF) deconvolutions of the chemical images to obtain high quality diffraction-limited (or higher) resolution. Deconvolution methodologies will be implemented at the beamline, and made available to Users. Figure 2 shows how the beamlets are extracted from the bending magnet and combined at the User end-station.

QUADRUPOLE POLE-TIP STEERING COILS

New pole-tip coils have been installed on selected quadrupoles in Aladdin. The coils were intended as a replacement for the backleg winding steerers placed on quadrupoles where the adjacent multipole was needed as a skew quad element. The other use they had been posited for was in the case of a short straight undulator where, in combination with the multipole steerers, they provided two vertical and horizontal correctors upstream and downstream of the insertion device allowing for both position and angle correction of the beam through the insertion device. They could also be used to free a multipole as a compensating optical element for an insertion device.

Several designs were tried with the constraints being that the coils have as large an amp-turn total as possible from the 22 volt source while still fitting in the tight geometry between the pole tips, without exceeding the thermal load associated with the coil resistive losses.

SUMMARY

The Aladdin storage ring at SRC continues to be upgraded in a number of ways to enhance its performance as a vacuum UV and soft x-ray light source. These include improvements to beam lifetime, new beamline capabilities, as well as ongoing improvements to beam stability and reliability.

ACKNOWLEDGEMENTS

We would like to thank John Wallace of the University of Wisconsin Nanoscale Science and Engineering Center (NSEC) and Michael Nasse of the University of Wisconsin-Milwaukee for their help with these projects, and their contributions to this paper.

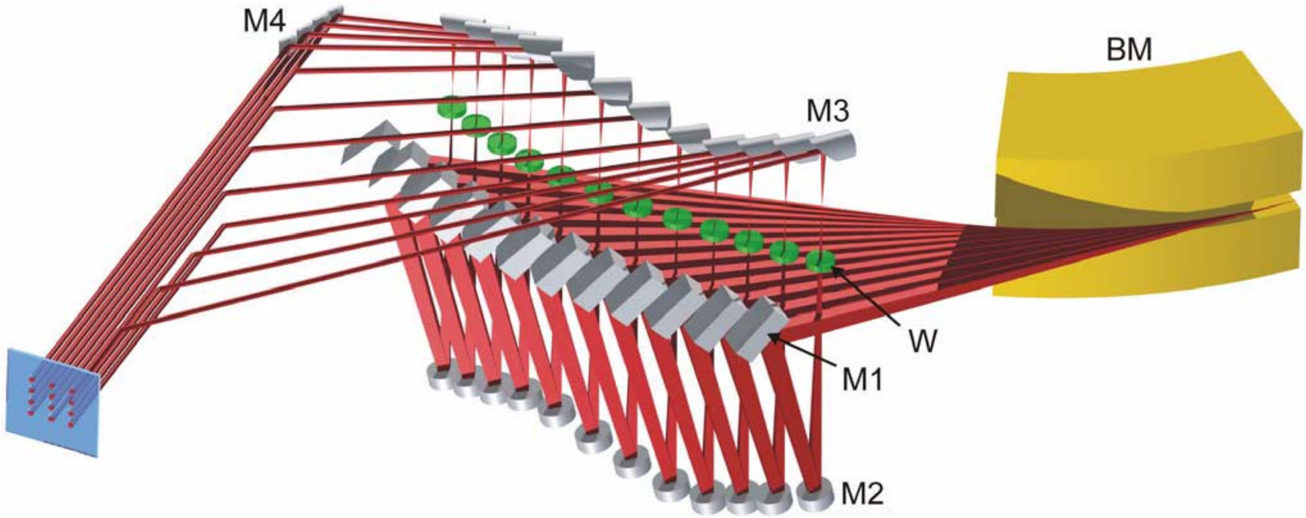

Figure 2: Extraction of light from a ring dipole for the new infrared beamline. The components are: Bending magnet BM, toroidal mirrors M1, flat mirrors M2, windows W, parabolic mirrors M3, and flat mirrors M4 (4 of 12 shown). The beamlets are combined into a 3×4 array at the sample location.

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1-4244-0917-9/07/$25.00